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STUDY OF MELT LOADING THE 105 MM M1 PROJECTILE WITH COMP B CONTAINING GRADE B WAX

Robert Pelien, et al

Picatinny Arsenal Dover, New Jersey

September 1975

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STUDY OF MELT LOADING THE 105 MM M1 PROJECTILE WITH COMP B CONTAINING GRADE B WAX

ROBERT PELLEN KENNETH RUSSELL MERCENTED

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SEPTEMBER 1975

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	ng Defects						
Grade P daxes		i					
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A process and material variables program was implemented to resolve production loading problems with the 105mm M1 shell. When Composition (Comp) B with Grade B wax was substituted for Comp B with Grade A wax, many of the							
explosive casts upon solidification contained cavities defined as critical defects. Comp B with three types of Grade B waxes, and one with Grade A wax were studied. The test variables consisted of explosive and shell temperature; effect of SPAN 85; water cooling; skid shroud design; shell position analysis;							
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20. ABSTRACT

effect of hot top-off; probing; split pouring; viscosity; laboratory tests; and others. From the tests it was determined that shell temperature before prur, and explosive temperature at pour are the most significant variables. By restricting shell temperature to a range of 65° to 79°F, the explosive pour temperature to 176° + 3°F, Comp B with Petrolite (ES670) or Indramic (170C) wax was used successfully on a regular production basis. Comp B using Castor wax was not successfully loaded within the limits. Use of SPAN 85, a surfactant was not helpful. A temperature variable study with Comp B using Sunoco 8810 (Grade A) showed that this material behaves quite differently and that shell temperatures in excess of 90°F can be tolerated. More effective shrouding of a poured skid is considered to be helpful, but not a prime factor. Other process variables, i.e., agitation, scrap level, riser height, cooling bay temperature, reservoir level, and skid temperatures, are judged to have some significance but are not prime factors. However, all of these are subtle factors in the sense they relate to an objective of maintaining a reproducible, controllable process.

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The authors gratefully wish to acknowledge the high degree of cooperation in this study and in other activities of the ad hoc committee with the 105mm loading problems, on the part of JAAP, in particular Mr. H. Miller, Mr. M. Shrode, and Mr. K. Blanchard.

The authors specifically wish to acknowledge Mr. Joseph Pulsifer (formerly of JAAP), who worked with the authors in set-up and conducting of the tests, recording and analyzing data, and in drafting preliminaries of this report. Mr. Pulsifer's expertise and dedication was invaluable in this effort.

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TABLE OF CONTENTS

<u>Pa</u>	ge
IST OF ILLUSTRATIONS v	i: /i: .x
. INTRODUCTION	1
1.1 Purpose	1 1 3 5
2.1 Gridding 2.2 Explosive and Shell Temperature Study 2.3 Effect of Span 85 2.4 Hot Top-Off 2.5 Probing 2.6 Hot Top-Off and Probing 2.7 Split Pouring 2.8 Water Cooling Test 2.9 Shroud Design Study 2.10 Shell Position Analysis 2.11 Viscosity 2.12 Fiber Washers 2.13 Bad Lot Petrolite 4	6 6 6 8 0 2 2 3 6 2 3 9 4 5 6
3.1 Wax Content	17 17 19 51
3.4 Split Photography 5 V. PRODUCTION PROCESS COMMENTS 5	53 55
4.2 Riser Height	55 55 56 57 57 58

TABLE OF CONTENTS (CON'T.)

Sect	Section								Page	
v.	CONCL	USIONS			• • • •	• • • •		• • • • •		. 59
	5.2	Proces	s		• • • •					. 59
VI.	RECO	MMENDAT	CIONS	• • •	• • • •	• • • • •	• • • • •	• • • • •		. 61
DIST	RIBUT:	ION LIS	T	• • • •						. 63

LIST OF ILLUSTRATIONS

Figure	<u> </u>	age
1.	105mm Ml Configuration	5
2.	105mm Ml Temperature Variable Study	
3.	Comp B W/Petrolite Wax, 3120 Shell	12
٥.	Comp B W/Petrolite Wax, 8880 Shell	12
4.	105mm Ml Temperature Variable Study	
	Comp B W/Indramic Wax, 6360 Shell	13
5.	105mm Ml Temperature Variable Study	1 2
6.	Comp B W/Castor Wax, 4980 Shell	13
0.	Comp B W/Sunoco 8810 Wax, 960 Shell	15
7.	105mm Ml Temperature Variable Study	
	Comp B W/Petrolite Wax W/.1% Span 85,	
8.	1800 Shell	17
٥.	Comp B W/Indramic Wax W/.1% Span 85,	
	960 Shell	17
9.	Pour Heights of Initial Pour in the	
10.	Riser for Hot Top-Off	18
10.	Probing Temperature Variable Study For Loading 105mm Ml With Comp B,	
	With Petrolite Wax, 5340 Shell	21
11.	Probing Temperature Variable Study	
	For Loading 105mm Ml With Comp P,	
12.	With Indramic Wax, 1920 Shell	
13.	Annular Ring Defect, Split Pouring Test	
14.	Water Cooled Skid	
15.	Close Up of Water Jacket	27
16.	Test W-1, Location of Defects	20
17.	Caused by Cavities	29
	Caused by Cavities	29
18.	Test W-4, Location of Defects	
10	Caused by Cavities	30
19.	Test W-5, Location of Defects Caused by Cavities	31
20.	Skid Covered With a Canvas Shroud	
21.	Skid Covered With Insulated Wood Shroud	33
22.	Skid With Wooden Shroud Components	34
23.	Air Temperature Under Wood Shroud With Baffle Versus Time Curve	
	(Sunoco Wax)	35

LIST OF ILLUSTRATIONS (CON'T.)

Figure	!	Page
24.	Air Temperature Under Wood Shroud With Baffle Versus Time Curve	
25.	(Petrolite Wax)	36
	("etrolite Wax)	36
26.	Ar Temperature Under Canvas Shroud Versus Time Curve (Petrolite Wax)	37
27.	Location of Shell Groups On a Skid	
28.	Total Defects Per Position For the Three Studies	
29.	Wax Analysis (%)	47
30.	RDX Analysis (%)	
31.	Density Analysis gm/cc	51
32.	Defect Caused by Glob of Wax	

LIST OF TABLES

Table		Page
I	List of Symbols	. 4
II	Summary of Results For Tests A-1 Thru A-9, Petrolite Wax Virgin Material	, 7
III	Summary of Results For Tests J-1 Thru J-4, Indramic Wax Virgin Material	. 7
IV	Summary of Results For Tests J-17	•
	Thru J-21, Indramic Wax Containing 40% Scrap	. 8
V	Summary of Results For Tests F-1 Thru F-4, Castor Wax Virgin Material	. 8
VI	Analysis of Variance For Petrolite	
VII	Wax (Based on Defect Count)	. 9
VIII	Indramic Wax (Virgin Material)	. 10
	Indramic Wax (Containing 40% Scrap)	. 10
IX	Analysis of Variance Table For Castor Wax	. 11
X	Summary of Results For Tests 9-1 Thru 0-4, Sunoco Wax Virgin Material	
XI	Results of Hot Top-Off Tests	
XII	Results of Hot Top-Off and	
	Probing Tests	. 23
XIII	Split Pouring	
VIV	Data on Special Split Poured Skid	. 25
XV	Water Cooling Test	
XVI	Shroud Test Conditions	
XVII	Shroud Maximum Temperatures	. 37
XVIII	Shroud Comparison	
XIX	Number of Defects Per Position	
	by Location	. 40
XX	Defect Summary Study by Position	
XXI	Results of Sorted High and Low	
	Viscosity Tests	. 44
XXII	Results of Test With and Without	
	Fiber Washers Between the Riser	
	and the Shell	. 45
XXIII	Results of Bad Lot Petrolite Tests	
VXXV	Wax Content	. 48
XXV	RDX Content	
XXVI	Density	. 52

SECTION I

INTRODUCTION

1. INTRODUCTION.

This report covers a series of process variables and material variable loading trials performed on over 40,000 shells at Joliet Army Ammunition Plant (JAAP) with the 105mm Ml projectile using a Comp B explosive fill. The work was undertaken as a result of extreme production difficulties when Comp B with Grade B wax was introduced into 105mm Ml loading operations during 1973.

1.1 PURPOSE.

There were two prime objectives for the work undertaken at JAAP.

- 1. To establish a suitable process for loading Comp B with Grade B wax in the 105mm projectile.
- 2. To obtain data that would provide more information about the 105mm melt loading problems, and provide a data base for laboratory efforts and analytical work at other facilities on the 105mm melt loading problems.

1.2 BACKGROUND.

Grade A desensitizing wax (primarily Sunoco 8810) was used for many years as the desensitizing wax in Comp B. In the recent past, sources of Grade A wax have no longer been available, and various Grade B waxes (primarily Indramic 170C and Petrolite ES670) have been used to manufacture Comp B. When Comp B with these Grade B waxes was introduced into the 105mm Ml loading operations at Kansas Army Ammunition Plant (KAAP) in the early spring of 1973, and later at JAAP, numerous cavitation defects in the "C" segment of the explosive cast occurred. The occurrence of these defects necessitated frequent and costly 100 percent radiographic inspection of the cast projectiles, and eventually necessitated return to loading with rapidly dwindling stocks of Comp B with Grade A wax.

An ad hoc committee was formed to resolve these problems, and the loading plant trials encompassed in this report is one phase of the effort coordinated by this committee. Other phases of the overall program included 1) laboratory work to characterize a large number of waxes and wax-like materials as possible substitutes, 2) loading trials with instrumented shell, 3) computer analysis to obtain a better understanding of melt pouring and the cooling cycle, 4) analysis of the significance of differing impurities in batch or continuous process TNT, 5) loading studies with other ammunition items at other load plants. These other programs are not covered in this report but are mentioned occasionally in the discussion.

Generally, Comp B with Grade B waxes did not cause undue problems in other projectiles. The reasons are either a different size and configuration such that the cooling cycle is not critical, or the item receives a 100 percent radiographic inspection which eliminates cavitation from production. Thus, the 105mm Ml shell, by dint of size, configuration, and large volume production became the focal item for the "wax problem" in Comp B loading.

The time period for the loading plant trials conducted at JAAP was August through November 1973. The report quantifies and identifies process variables and their effect on production and presents the results of loading trials conducted on a production scale. These tests were conducted by JAAP production and engineering personnel, in conjunction with Picatinny Arsenal resident engineers. A full scale production line known as Group 3 was used for all loading trials.

All projectiles used in the loading trials were manufactured by National Presto. All Comp B was produced at Holston AAP. The new waxes used were Petrolite ES670. Indramic 170C and Castor wax. The specification for the 105mm Ml cartridge (MIL-G-45195C) was the document used to define acceptable explosive cast quality.

Joliet AAP returned to full production use of Comp B with Grade B wax on 26 September 1973. Production has used Comp B with both Petrolite ES670 and Indramic 170C wax. This has continued to date, and has been successful. Return to successful full production resulted from implementation of established control limits on shell and explosive temperature, and the manufacture and use of a more efficient shroud assembly.

1.3 REPORT ORGANIZATION.

This report is comprised of six sections; and four appendices:

Section I	Introduction.
Section II	Process Tests and Studies - discusses the process and material tests, test procedures, and results.
Section III	Laboratory Tests - discusses laboratory analysis of Comp B for wax content, RDX content, and density.
Section IV	Production Process Comments - discusses in general terms the process variable effects on cast loading of the 105mm Ml shell.
Section V	Conclusions.
Section VI	Recommendations.
Appendix A Appendix B Appendix C Appendix D	Cavitation Requirements. Projectile Weight Study. Physical Property Data. Test Data - provides detailed test procedures and results of test groups A through Q.

Table I provides a list of symbols used in this report.

TABLE I

LIST OF SYMBOLS

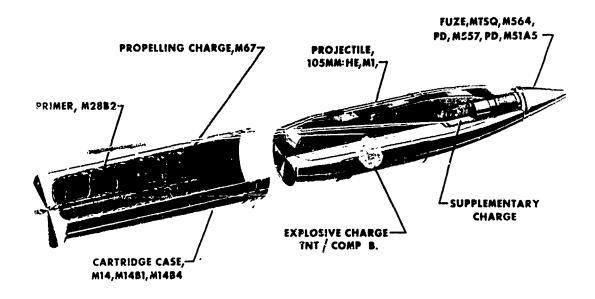
Symbol	Description
0	Skid with no defects (used on figures 2 thru 8, 10 and 11).
Δ	Skid with defects - number inside or outside tri- angle indicates number of defects per skid. (Used on figures 2 thru 8, 10 and 11).
•	Solid Circle - High defect position or cavity (Used on figures 16, 17, 18, 19 and 28).
\bigcirc	Semi-solid circle - Low defect position (Used on figure 28).
0	Air Temperature around risers in center of skid (Used on figures 23 through 26).
0	Outside temperature of shell at a point 6.5 inches from base (Used on figures 23 through 26).
◊	Outside temperature of shell immediately above rotating band (Used on Figures 23 through 26).

SECTION II

PROCESS TESTS AND STUDIES

2. CENERAL.

When this program was initiated there were two goals established. The first and most immediate goal was to find a satisfactory process to cast acceptable 105mm shells with Comp B manufactured with Grade B wax (See Figure 1). The second goal was to define the significant variables in the process, and to obtain better insight to cast loading variables and problems. In pursuit of these goals, the first variables studied were shell and explosive temperature.



CARTRIDGE,105MM: HE,M1 W/FUZE (FOR HOWITZER, M2A1, M2A2, M103, M137)

Figure 1. 105mm Ml Configuration

2.1 GRIDDING.

的对象不是一个人,他们是一个人,他们们们是一个人,他们们们是一个人,他们们是一个人,他们们是一个人,他们们是一个人,他们们是一个人,他们们是一个人,他们们们们的

When the test program was initiated, it was thought necessary to have quantitative means to evaluate the size of cavities, in lieu of "critical", "minor" or "less than minor" as specified by the cartridge specification. A method was established to overlay the X-ray film with a transparent grid and count the blocks the cavity encompassed. This method yielded quantitative results, but was time consuming. As testing progressed, it became apparent that occurrence of cavitation was either considerable, or non-existent; and a more precise quantitative evaluation did not assist in evaluation of X-ray results. After several tests, gridding was discontinued and specification criteria for defects was used for the remaining tests.

2.2 EXPLOSIVE AND SHELL MEMPERATURE STUDY.

2.2.1 Temperature Variables for Grade B Waxes.

A temperature variable study was performed on Comp B manufactured with the following waxes:

- 1. Petrolite ES 670 wax (Grade B)
- 2. Indramic wax 170C (Grade B)
- 3. Castor wax (Grade B)

The initial results of the Grade B studies are given in Tables II through V. These tables show the nominal temperatures and actual temperatures for each skid. The number of defective shells produced for each skid is also shown (full skid has 60 shells).

Table II. SUMMARY OF RESULTS FOR TESTS A-1 THRU A-9, PETROLITE WAX VIRGIN MATERIAL

Nominal Shell Temperature °F												
	70°F				80°F			90°F				
No. Exp Temp °F	No. of Def*	Def Area	Actl Shell Temp	Actl Exp Temp		Def Area	Actl Shell Temp	Actl Exp Temp	No. of Def	Def Area	Actl Shell Temp	Actl Expl Temp
176	0 0 1 0	0.0 0.0 14.0 0.0	78 72 73 70	174 173 172 174	8 : 2 2 1	179.5 42.0 59.0 17.5	82 82 80 80	176 176 176 176	12 15	264.0 244.0 313.0 674.0	90 90 93 90	176 176 176 176
178	0 1 0 0	0.0 26.5 0.0 0.0	75 70 70 69	180 180 179 180	0 0 0	0.0 3.0 3.0 2.0	80 82 80 81	177 177 179 179	40 12	862.5 871.5 224.5 182.0	92 92 91 90	182 180 182 180
184	3 1 0 0	78.0 37.5 0.0 0.0	70 75 75 77	183 185 185 182	2 0 0 1	57.5 0.0 0.0 24.5	80 80 80	185 183 184 181	42	734.0 213.5 860.0 961.0	92 92 92 93	183 183 184 183

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*Defect

TABLE III. SUMMARY OF RESULTS FOR TESTS J-1 THRU J-4, INDRAMIC WAX VIRGIN MATERIAL

Nominal Shell Temperature °F									
		70°F		90°F					
Nom	Number	Actual	Actual	Number	Actual	Actual			
Exp	of	Shell	Exp	of	Shell	Exp			
Temp °F	Defects	Temp	Temp	Defects	Temp	Temp			
176	0	72	175	2	92	175			
	0	71	176	16	92	176			
	0	71	176	15	93	176			
	0	72	175	21	93	176			
184	0	72	186	47	90	188			
	0	71	186	52	90	187			
	0	70	185	57	93	189			
	0	70	183	56	94	188			

TABLE IV. SUMMARY OF RESULTS FOR TESTS J-17 THRU J-21, INDRAMIC WAX CONTAINING 40% SCRAP

The state of the s

Nominal Shell Temperature °F								
		75-79°F		80-85°F				
Nom Exp Temp °F	Number of Defects	Actual Shell Temp	Actual Exp Temp	Number of Defects	Actual Shell Temp	Actual Exp Temp		
180	0 0 0 0	78 76 75 76 76	180 180 181 180 179	0 0 1 0 0	85 84 85 84 82	180 180 180 180		
184	0 0 0 0 4	76 76 77 76 78	182 184 184 183 183	6 3 1 13 1	84 83 84 84 82	184 185 185 184 184		

TABLE V. SUMMARY OF RESULTS FOR TESTS F-1 THRU F-4, CASTOR WAX VIRGIN MATERIAL

Nominal Shell Temperature °F									
		70°F		90 ° F					
Nom	Number	Actual	Actual	Number	Actual	Actual			
Exp	of	Shell	Exp	of	Shell	Exp			
Temp °F	Defects	Temp	Temp	Defects	Temp	Temp			
176	0	70	179	10	92	176			
	0	72	177	0	93	174			
	0	69	176	1	92	174			
	0	74	176	3	92	175			
184	0	70	185	15	93	182			
	0	70	186	11	90	182			
	1	70	186	24	92	184			
	0	70	.187	19	92	184			

2.2.1.1 Variance Analysis, Grade B Waxes.

An analysis of variance for a two way classification was performed on these results. The results for these analyses are shown in Tables VI through IX. From these analyses, it can be concluded that shell and explosive temperatures are significant variables in the production of good explosive casts. It should be pointed out that this was not true for all of the studies. Explosive temperature was found not to be statistically significant in the temperature variation study for Comp B manufactured with Indramic wax (when used with 40% scrap) and Petrolite wax. This was probably due to the fact, that in the shell temperature ranges chosen, material temperature was not significant. An F value larger than F statistic indicates significance. An F value smaller than F statistic indicates lack of significance.

"ABLE VI. ANALYSIS OF VARIANCE FOR PETROLITE WAX (BASED ON DEFECT COUNT)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	F Statistic (.05)
Shell Temp	6127	2	3063	49.6	3.35
Exp Temp	178	2	89	1.44	3.35
Interaction Be- tween Shell and Exp Temperature	445	4	111,25	5 1.80	2.75
Error	1666	27	61.7		
Total	8416	35			

TABLE VII. ANALYSIS OF VARIANCE TABLE FOR INDRAMIC WAX (VIRGIN MATERIAL)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	F Statistic (.05)
Shell Temp	1560.2	1	1560.2	72.3	4.75
Exp Temp	4422.2	1	4422.2	204.9	4.75
Interaction Be- tween Shell and Exp Temperature	1560.3	1	1560.3	72.3	4.75
Error	259.0	12	21.6		
Total	7801.8	15			

TABLE VIII. ANALYSIS OF VARIANCE TABLE FOR INDRAMIC WAX (CONTAINING 40% SCRAP)

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	F Statistic (.05)
Shell Temp	36.4	1	36.4	5.10	4.75
Exp Temp	22.0	1	22.0	3.08	4.75
Interaction Be- tween Shell and Exp Temperature	18.0	1	18.0	2.52	4.75
Error	114.4	16	7.2		
Total	190.9	19			

TABLE IX. ANALYSIS OF VARIANCE TABLE FOR CASTOR WAX

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	F Statistic (.05)
Shell Temp	196.0	1	196.0	15.22	4.75
Exp Temp	420.2	1	420.2	32.64	4.75
Interaction Be- tween Shell and Exp Temperature	182.2	1	182.2	14.16	4.75
Error	154.5	12	12.88		
Total	953.0	15		um title	

2.2.2 Figures 2 through 5 show the results of all skids which were single poured, not probed, or otherwise handled in a manner different from the original process, except an insulated wood shroud and baffle was used on all skids. These graphs generally outline the operating region which produces acceptable shells. The primary emphasis was placed on the maximum shell temperature. (There is also a lower shell temperature below which defects can be produced). The results obtained for Indramic and Petrolite waxes were Indramic wax Comp B produced no defective very encouraging. shell where projectile temperatures were less than 82°F and explosive less than 182°F. Petrolite wax Comp B produced several skids with defects with a shell temperature less than the 79°F. Most of the defects have an assignable cause. The one which accounts for most of the defects was that the shell was cooled with water prior to loading in an attempt to obtain the desired shell temperature. Thus there was uneven cooling and one or two shells may have been above 79°F when poured. The whole problem evolves from the fact that there were no provisions to cool shells on hot days, thus water cooling with a water hose to lower the steel temperature was utilized. Fortunately, this problem was only encountered in the early days of the testing program. The results from these tests indicate that Indramic and Petrolite Comp B can be poured satisfactorily provided the shell temperature is between 65° and 79°F. The results obtained for Castor wax were disappointing in view of preliminary data in Table III. There was an indication that a shell temperature of 70°F and an explosive temperature of 174°F to 180°F may produce acceptable casts, but there was insufficient data to substantiate this. The conclusion obtained from this data was that Castor wax is unacceptable.

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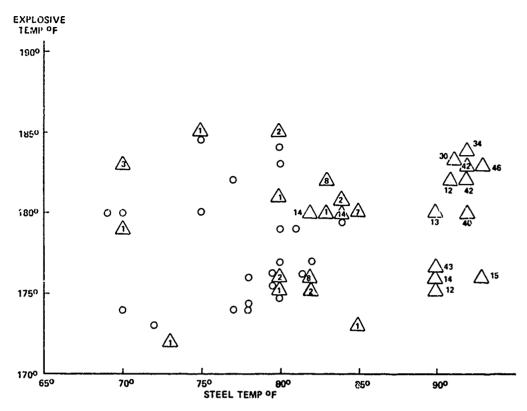


Figure 2. 105mm Ml Temperature Variable Study Comp B W/Petrolite Wax, 3120 Shell

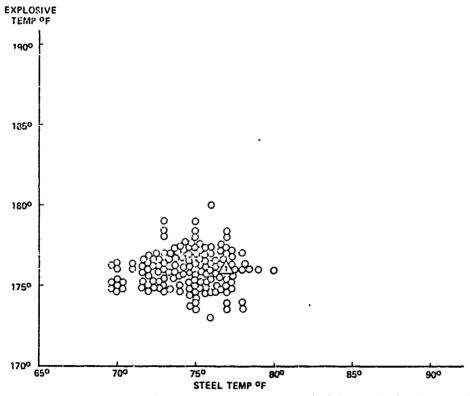


Figure 3. 105mm Ml Temperature Variable Study Comp B W/Petrolite Wax, 8880 Shell

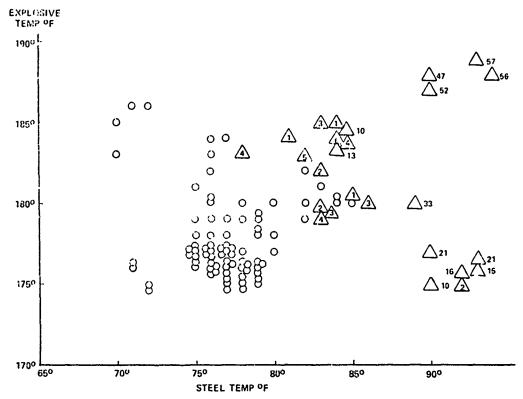


Figure 4. 105mm Ml Temperature Variable Study Comp B W/Indramic Wax, 6360 Shell

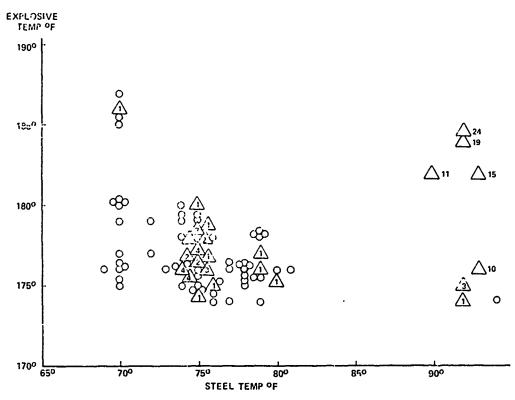


Figure 5. 105mm Ml Temperature Variable Study Comp B W/Castor Wax, 4980 Shell

2.2.3 Temperature Variables for Grade A Wax (Sunoco 8810).

A major result of this study is the emergence of data showing that the wax can have a significant, and even overriding effect in the quality of the Como B cast. The significance is demonstrated by comparing the results of the temperature variable study of Comp B with Sunoco 8810, to the similar studies with Comp B with Petrolite or Indramic wax, discussed in 2.2.1. For example, with Sunoco 8810 only one defect occurred in a total of 8 skids (480 shells) poured, at shell temperatures of 90°F or higher, and with explosive at 179 F or higher (see Table X and Figure 6). There were no defects in a similar test with shell at 80°F and explosive at 179°F to 184°F. With Indramic or Petrolite, the combination of shell at 90°F or higher, and explosive at 179°F or higher, gives defect rates in the range of 50 to 100%. Loading the shell with Indramic or Petrolite at or near 80°F with explosive at 180°F or higher, provides a 2 to 10% defects rate. Taking shell temperature as the prime variable, the maximum for the Grade B waxes is near 80°F, while the Grade A (Sunoco) wax can tolerate shell temperatures in excess of 90°F.

TABLE X. SUMMARY OF RESULTS FOR TESTS 0-1 THRU 0-4, SUNOCO WAX VIRGIN MATERIAL

	- 1					
	Nom	inal She	ll Tempe	rature °F	•	
	80°F			90°F		
Nom Exp Temp °F	Number of Defects	Actual Shell Temp	Actual Exp Temp	Number of Defects	Actual Shell Temp	Actual Exp Temp
180	0 0 0	80 80 80	180 180 180 180	0 0 0	91 90 95 95	179 179 180 180
184	0 0 0	80 80 81 81	182 183 182 184	0 0 1 0	94 90 94 96	185 185 185 184

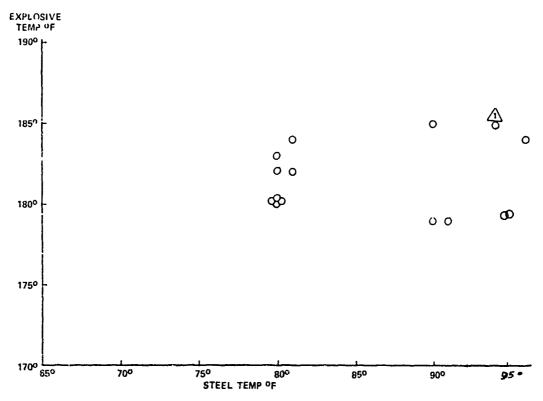


Figure 6. 105mm Ml Temperature Variable Study Comp B W/Sunoco 8810 Wax, 960 Shell

These data are confirmed with hindsight to prior production experiences. First, the Sunoco 8810 wax has been the wax used almost exclusively in Comp B for several years. There were at least five seasonal cycles where Comp B with Grade A wax was loaded in the 105mm Ml shell in summer months, without undue difficulty. While there were defects and rejects in these periods, the ratio was not such that the basic load plant production capabilities were compromised, or that the sampling plans and inspection criteria became unworkable. Summer operations at Joliet, Kansas or Lone Star AAP certainly involved use of shells at temperatures over 90°F and probably nearer to 100°F on occasion. There were other Grade A waxes also utilized, namely Witco A and Witco A/B. While not studied specifically in this effort, a review of prior production experience suggests they seemed to behave more like Suncco 8810 than Grade B waxes in current use. In any event, they did not cause rejects to the extent that loading capabilities were compromised.

A second point regarding the influence of Sunoco 8810 is the production experience in the summer months of 1973. At both Joliet and Kansas AAP, following the initial difficulties with Petrolite and Indramic waxes, production loading was done with mixtures of Comp B with Grade A wax and Comp B with Grade B wax. The proportions ranged from 1 part Grade A with 1 part Grade B, up to 1 part Grade A with 3 parts Grade B. Mixing

was done at the time, to extend the available supplies of Grade A wax. The results of mixing were satisfactory; as evidenced by the fact that no undue problems occurred in maintaining required cast quality confirmed by radiographic inspection.

Thus, it seems that the Sunoco 8810 wax contains an ingredient which acts as a casting aid, and which significantly broadens the range of temperatures for both the metal parts and the explosive, to yield an acceptable cast. Further, it seems that only a small amount of this ingredient is necessary from the mixing experiences. This is consistent with Picatinny Arsenal laboratory data showing that waxes are soluble in TNT to a very limited extent -- less than 0.1%. Therefore, the fraction or element which is soluble, and identifying the effect it can have on crystallization of TNT may be the key to a better understanding of the shell loading process. This aspect is being followed up by Picatinny Arsenal and others. Attention has focused on hexanitrostilbene (HNS), known from literature to be a nucleating agent for TNT, on Biphenyl which like HNS is a double ring compound (Biphenyl is known to be in Sunoco 8810), and on other double cyclic compounds which are known to exist in continuous process TNT.

2.3 EFFECT OF SPAN 85.

Span 85, a surfactant, has been used (optionally) in the production of Comp A3 and other RDX/wax systems, where it was desirable to maximize the degree of wax to crystal contact, and to have a uniform distribution of wax. With the observations of the greater tendency for Grade B waxes to segregate in Comp B, the same agent was evaluated. There were reasons to think the cast quality problems were related to the segregation of the wax.

In an attempt to prevent the separation of the wax from the explosive, 0.1 percent Span 85 was added. Two waxes with Span 85 were tested, Indramic and Petrolite. Figures 7 and 8 show the results of these tests. The results for Indramic wax show no improvement at 85°F shell temperature. The results for Petrolite wax were worse. Defects were found on skids with shell temperatures less than 79°F. In this case, the addition of Span 85 was apparently detrimental to the process under study. Observations made during the tests indicated that there was no decrease in the amount of wax separation in the melt kettles, or on the top of the risers in the case of Indramic wax. In conclusion, Span 85 does not significantly aid in the production of acceptable 105mm shells.

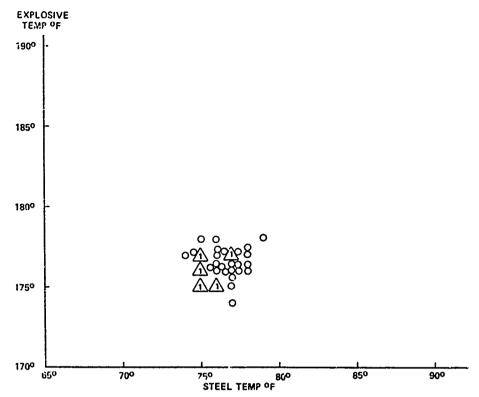


Figure 7. 105mm Ml Temperature Variable Study Comp B W/Petrolite Wax W/.1% Span 85, 1800 Shell

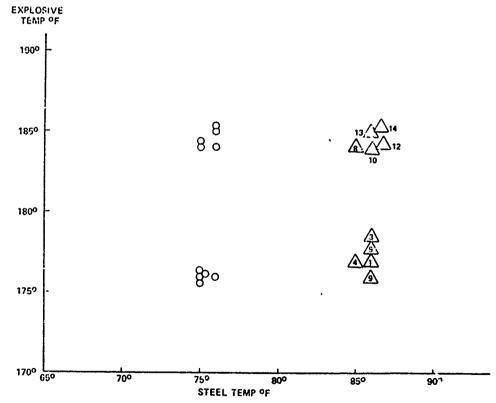


Figure 8. 105mm Ml Temperature Variable Study Comp B W/Indramic Wax W/.1% Span 85, 960 Shelf

2.4 HOT TOP-OFF.

The purpose of the riser portion of the riser-former used in conjunction with cast loading is to provide a reservoir of heat and molten explosive to fill voids created by the shrinkage of the solidifying explosive. However, if the neck of the riser freezes before the charge in the central portion of the shell solidifies, a void or a porous charge could result. In the present 105mm Ml shell design with the metal riser-former design, the rate of heat loss is lowest in a central area about 6 to 9 inches below the nose of the shell. Solidification of the cast occurs from the bottom up, side walls in, and top down leaving an isolated molten interior about 6 to 9 inches below the nose of the shell. fication occurs in the neck of the riser-former (adjacent to the middle of the shell threads) within about thirty (30) minutes of casting, whereas the central portion of the shell solidifies within about 1 to 1-3/4 hours.

Hot top-off was a proposed solution to prevent formation of cavities. The idea was to put additional heat into the riser, and thus prolong the time before the explosive in the former section of the riser solidified. The procedure was to pour the bulk of the explosive at the normal pour temperature. Two different pour heights were tried (see Figure 9):

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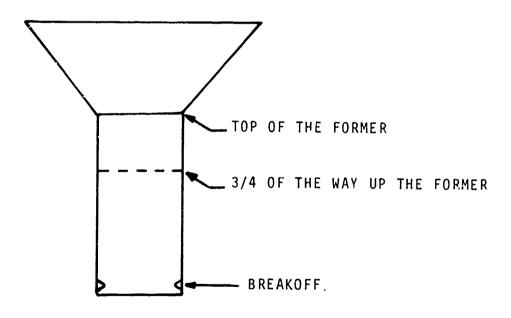


Figure 9. Pour Heights of Initial Pour in the Riser for Hot Top-Off

The skid was then moved to a second multipour where the remainder of the explosive was poured. The top-off temperature was 200°F, versus the 176° or 184°F for the explosive temperature in the initial pour. The explosive was Composition B manufactured with Petrolite wax and sorted to a viscosity of 5 seconds or less. The results of these tests are shown in Table XI. The results do not show that allowable shell temperature can be higher than that for the simple single pour process. This process would be difficult to implement due to the two separate pouring operations.

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TABLE XI. RESULTS OF HOT TOP-OFF TESTS

Height of First Pour	Shell Temperature		Explosive Temperature Top-Off	Defects
Top of former	84	178	194	2
Top of former	84	177	195	1
Top of former	82	176	198	0
Top of former	80	176	198	1
Top of former	80	185	198	0
Top of former	80	184	198	0
Top of former	80	184	192	0
Top of former	80	183	193	0
3/4 way up former	80	178	198	1*
3/4 way up former	80	184	194	0
3/4 way up former	80	178	194	0
3/4 way up former	80	178	194	0

^{*}Most of the shells on this skid were poured too low to produce an acceptable cast.

TABLE XI (Continued)

Height of First Pour	Shell Temperature		Explosive Temperature Top-Off	Defects
3/4 way up former	80	184	-	0
3/4 way up former	82	184	200	0
3/4 way up former	-	184	200	0
3/4 way up former	82	184	200	0

The explosive was Composition B manufactured with Petrolite wax and sorted to a viscosity of 5 seconds or less.

2.5 PROBING.

Probing was proposed as another method to introduce additional heat into the riser. The theory was that additional heat added after the explosive was poured into the shell would increase the time delay before the explosive solidified in the neck of the riser. Probe depths from 1 inch to 4 inches above the break-off point, and dwell time of 5 seconds to 15 minutes Details are in Appendix D, Test Groups C, D, E, J and K. A broad summary of results is shown in Figures 10 and 11, for Petrolite and Indramic waxes. These figures combine the data for all conditions of probe depth and time. The results do not show any advantages derived from probing. technique of probing does not overcome the detrimental effect of a hot projectile. The defects when steel temperature was below 80°F may be attributed to the fact that the probe mechanism may have come in contact with the riser, thus adding heat to the shell center in addition to the riser (see Figure 12). The conclusion was that probing will not help prevent the formation of cavities. It was also demonstrated that probing introduced other operational difficulties and made the loading process more complicated.

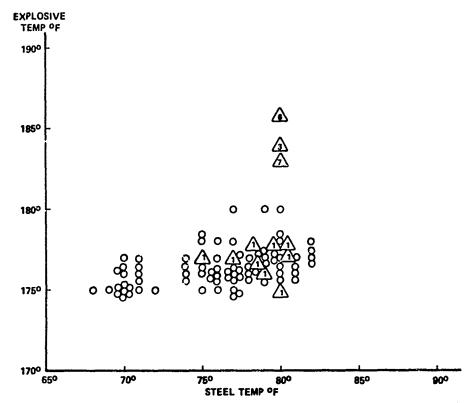


Figure 10. Probing Temperature Variable Study For Loading 105mm Ml With Comp B, With Petrolite Wax, 5340 Shell

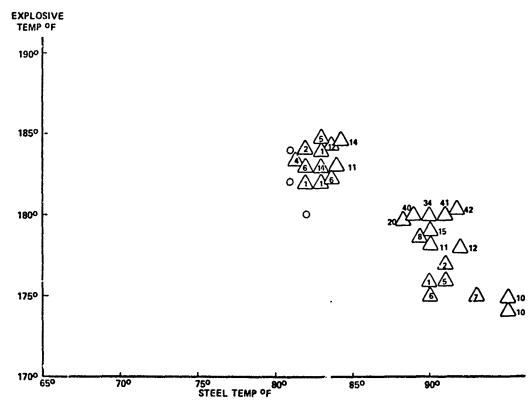


Figure 11. Probing Temperature Variable Study For Loading 105mm Ml With Comp B, With Indramic Wax, 1920 Shell

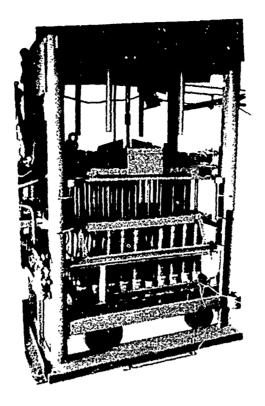


Figure 12. Probing a Skid (Note the Probe in Contact With the Riser in the Center of the Skid)

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2.6 HOT TOP-OFF AND PROBING.

There were three sets of tests performed to determine if a combination of a hot top-off and probing could produce acceptable casts. The procedure was to pour the bulk of the explosive at 176 ± 2°F. The pour height was three quarters the way up the former, (see Figure 9). The skid was then transported to a second multipour where the remainder of the explosive was poured at 195° to 200°F. The skid was then moved to a probe machine, probed for the time period shown in Table XII, and then placed in a cooling bay. Between the second pour and probing, the skid was covered with a shroud. The results from these tests are presented in Table XII. The occurrence of defects using projectiles at or near 80°F shows no improvement over the simple single pour process. These data and the obvious production complications were the bases for discontinuing this approach.

TABLE XII. RESULTS OF HOT TOP-OFF AND PROBING TESTS

Probe Time	Shell Temperature	Explosive Temperature First Pour	Explosive Temperature Top-Off	Defects
15 Seconds	80	176	195	1
	80	177	195	0
	80	177	195	0
	80	178	198	0
2.5 Minutes	80	177	197	1
	80	177	197	1
	81	177	195	0
	-	178	191	0
5 Minutes	81	176	202	0
	81	176	200	0
	81	176	199	0
	81	177	200	0

The explosive was Composition B manufactured with Petrolite wax with a viscosity of 5 seconds or less.

2.7 SPLIT POURING.

The purpose of split pouring was to allow the lower portion of the explosive cast a lead time to start solidifying, before the remainder of the explosive was poured into the shell. The procedure was to pour approximately 50% of the explosive into the shell, then allow a 1 to 3 minute delay before the remainder of the explosive is poured. The skid was cooled in the usual manner. The results of these tests are shown in Table XIII. From these results it is apparent that split pouring does not provide any significant improvement to the process when the steel shell temperature is above 79°F.

TABLE XIII. SPLIT POURING

<u> Indramic - Double Pour</u>

40% Scrap

Steel 90° + 2°

Expl 180° + 2°

50% Explosive Charge Increments

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No. Shell	Pour Delay	Defe Crit.	ects Minor
180	1 Min	34	22(1)
180	2 Min	55	48
180	3 Min	40	65
120(2)	Straight Pour	12	33

- (1) Includes one defect free skid
- (2) Includes last skid from low reservoir

Prior to these tests an extra skid was poured in two increments. Table XIV provides the process data. The initial pour consisted of approximately 50% of the total. After a 3 minute delay, the remainder of the explosive was poured. All of the shells were X-rayed and found to be acceptable. Upon sawing a shell in half and examining the explosive cast, an annular ring was noted. Figure 13 shows the explosive cast typically found from all split poured shells. From this skid it was concluded that split pouring may cause more problems than it solves.

TABLE XIV. DATA ON SPECIAL SPLIT POURED SKID

9-20-73 Date: Explosive: Composition B Manufactured With Petrolite Wax Sorted High Viscosity 75°F Shell Temperature: Explosive Temperature: 176°F 83°F Average Cooling Bay Temperature: Shroud Time: 75 minutes First Pour: Approximately 40% of total volume Time Delay Between Pours: 3 minutes X-Ray Results *No defects were found

*Annular ring discovered upon sawing shell.

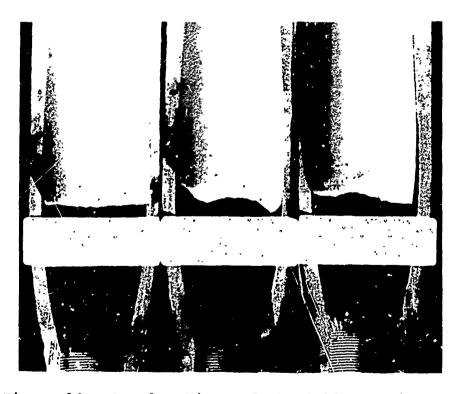


Figure 13. Annular Ring Defect, Split Pouring Test

2.8 WATER COOLING TEST.

2.8.1 General.

The primary purpose of water cooling tests was to increase the rate of heat removal from the base of the shell, thus increasing the rate of solidification of the explosive in the bottom section of the shell. The expected end result, when using water cooling, was to have a smaller mass of molten explosive in the center of the cast when the explosive in the neck of the riser solidified. After the neck of the riser is blocked by cast solidification, any additional shrinkage which takes place will result in either a low density volume of explosive, or a cavity, depending on the amount of shrinkage. Using this process, it was anticipated that "hot" shells (79-95°F) could be loaded satisfactorily with Comp B with Grade B wax. A reasonable expected side benefit for this process is a decrease in the cooling period for the shells.

2.8.2 Water Jacket Construction.

To permit water cooling, a skid rack was placed inside a water jacket which was equipped with an inlet and four outlets (see Figures 14 and 15). The inlet was located between shell positions 6 and 12. The outlets were located bewteen shell positions 43-47 and 49-55 at 1/2, 1-1/2, 3-1/2 and 5-1/2 inches from the bottom of the water jacket. The sides of the water jacket were 6 inches high.

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2.8.3 Test Procedure.

Prior to pouring, the appropriate outlet nozzle was opened and the water flow adjusted to a predetermined flow rate. The explosive was then poured into the shells and the skid transported to its cooling location. The inlet and outlet hoses were connected to the water jacket. The water flow, if any, after the prescribed depth was obtained, was maintained until the shroud was removed (75 minutes after pouzing). Immediately after the shroud was removed, the water flow was terminated and the water jacket drained. See Table XV for tests summary.

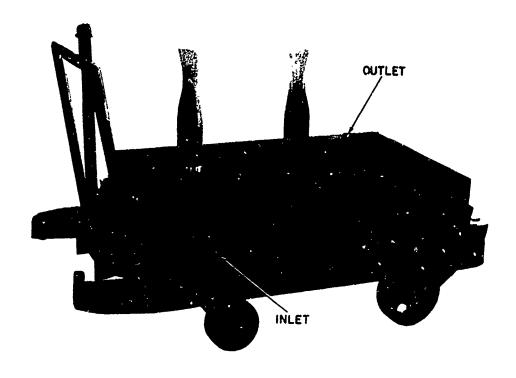


Figure 14. Water Cooled Skid

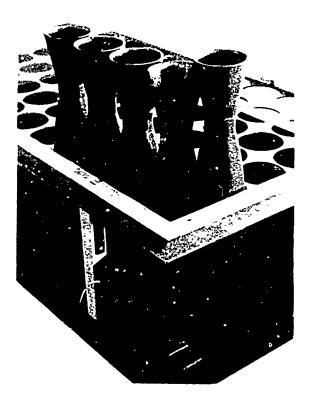


Figure 15. Close Up of Water Jacket

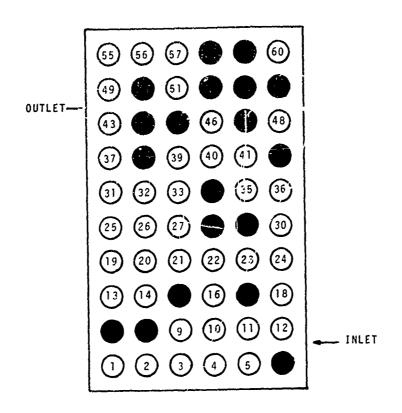
TABLE XV. WATER COOLING TEST

					
	Wl	W2	W3	W4	W 5
Date	10/9/73	10/11/73	10/11/73	10/15/73	10/16/73
Skid	7	12	12	18	20
Rsvr Temp (°F)	184	182	190	186	182
Cup Temp (°F)	181	180	178	184	180
Matl Temp (°F)	179	180	179	185	187
Shell Temp (°F)	89	88	87	93	93
Duration of Pour (sec)	45	43	98	35	47
Multipour No.	2	2	2	2	2
Lot HOL-	053-5030	053-5030	053-5030	053-2150	053-5095
Wax Type	В	В	В	A	В
Washers	No	No	Yes	Yes	Yes
Water Hgt (inches)	3.5	3.5	6.0	6.0	6.0
Flow Rate (gpm)	0	2.5	2.2	2.3	0
Inlet Temp (°F)	70	68	65	65	76
Cooling Bay	Sump	Sump	Sump	Sump	7
Shells Poured	60	60	60	60	60
Criticals	6	2	0	38	2
Minors	13	2 3 5	0	17	1 3
Cavities	19	5	0	55	3
Good Shells	41	55	60	0	57

2.8.3.1 Test W-1. There was a 5°F difference between the water temperature near the inlet and outlets 11 minutes after the skid was poured, with a water depth of 3.5 inches and no flow. Cavities developed in 19 shells (see Figure 16).

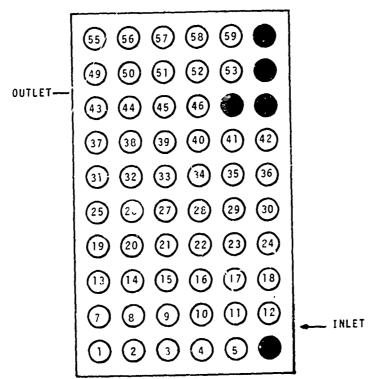
2.8.3.2 Test W-2. Under flow conditions of 2.5 gpm, and a water depth of 3.5 inches, there was a 17°F water temperature difference between the inlet and outlets 12 minutes after the skid was poured. There was also a difference of 2° and 10° in the water temperature near the bottom versus the top of the water bath. Cavities developed in 15 shells (see Figure 17). As a result, shell position becomes important, because some shells will receive more or less cooling depending upon their location on the skid.

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Figure 16. Test W-1, Location of Defects Caused by Cavities

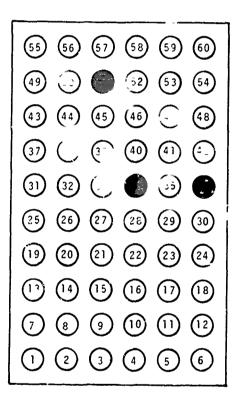


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Figure 17. Test W-2, Location of Defects Caused by Cavities

2.8.3.3 Test W- . Of the five skids poured, only one (Test W3) appeared to L. defect-free from X-ray results. Upon sectioning one of the shells, extensive cracking was observed in the cast. This was a different type of defect not previously observed and not detectable with the existing X-ray equipment. Upon this discovery, the additional shells on this skid were considered rejects and steamed out for reuse.

2.8.3.4 Test W-4. The results for Test W4 were equally disappointing due to a large number of shells which had cracks in the "A" segment on the X-rays, and the almost total lack of shells which did not have any voids in the "C" segment. The most significant fact was that Grade A Comp B was used. Using 93°F shell temperature, no defects were expected to be found in this skid. Cavitics developed in 55 shells (see Figure 18).

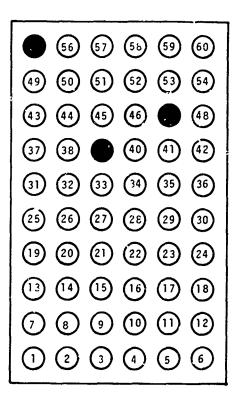


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Figure 18. Test W-4, Location of Defects Caused by Cavities (Not Including Cracks)

2.8.3.5 Test W-5. Results of Test W5 at a water height of 6 inches, and a no flow condition are shown in Figure 19.



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Figure 19. Test W-5, Location of Defects Caused by Cavities

2.8.4 On the last three water cooled skids fiber washers were inserted between the riser and the shell to determine if partially insulating the riser from the shell would leave any effect on cavity formation. Theory was that by partially isolating the riser from the shell, there would be less heat transfer from the riser to the siell, and thus a decrease in the solidification rate of the explosive in the neck of the riser. Refer to the discussion on fiber washers 2.12. The results of tests with fiber washers were also disappointing.

Although the results were disappointing, the authors feel more work should be performed before totally discarding water cooling. Much was learned from these few tests about water cooling. The major disadvantage to the described apparatus was the poor flow pattern. Temperature gradients were observed throughout the skid. These gradients were more pronounced during the start of the cooling period. This process was not found to be a simple process by which cooling shells could be speeded without careful consideration as a major process variable which may have to be precisely controlled. If future consideration is given to water cooling, a detailed process study must be undertaken correlating the effects of water temperature, flow rate, flow pattern, depth, initial steel and explosive temperature, etc. Careful consideration must be given to the cracking problem which was not detectable by existing X-ray equipment.

2.9 SHROUD DESIGN STUDY.

Canvas shrouding of the skid has been a long time practice after melt loading of 105mm shells, (see Figure 20). Prior to the start of this project, the Ad hoc Committee decided to design and test a more efficient shroud to replace the long used canvas shroud. The design consisted of an insulated wood shroud, and baffle. The purpose of this design was to decrease the rate of heat transfer from the enclosed metal parts, thus maximizing the opportunity for explosive mass flows from the riser to the shell center. This it was thought would be accomplished firstly by maintaining the maximum possible air temperature, and secondly to provide a uniform air temperature around the top of the shell. Figures 21 and 22 show a skid with the wood shroud and baffle. The wood shroud was designed so that there was no contact between the risers and the shroud; this was necessary to prevent any concentricity problems in the fuze well.

During testing which was performed to determine effect of shroud design, additional data was obtained regarding air temperature around the risers. This data was in form of air temperatures around the risers versus time after pouring of the shells. Data was obtained for the following shroud designs:

- 1. Canvas shroud
- Wood shroud without baffle
- 3. Wood shroud with taffle

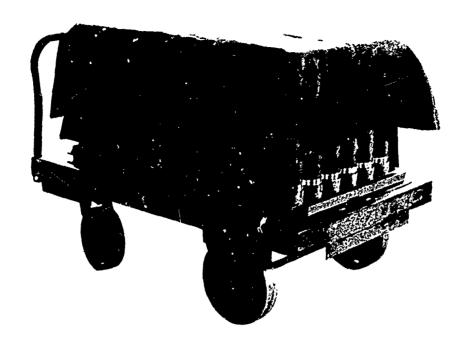


Figure 20. Skid Covered With a Canvas Shroud

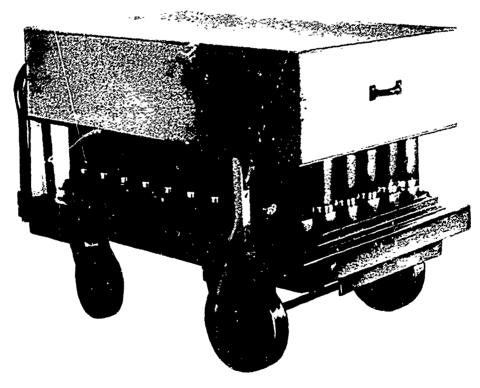


Figure 21. Skid Covered With Insulated Wood Shroud

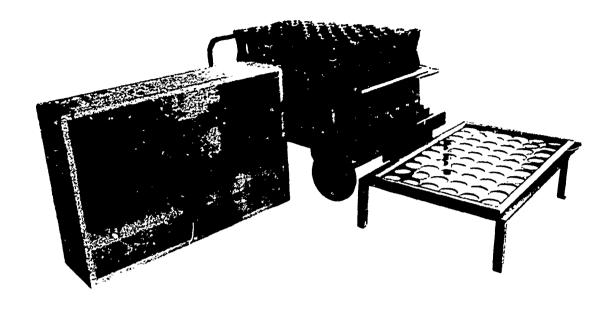


Figure 22. Skid With Wooden Shroud Components

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In some cases, the steel temperature of the shell was also obtained at one or two locations of the shell below the baffle. Test conditions are shown in Table XVI, the resulting curves are shown in Figures 23 through 26. The horizontal axis is time in minutes after the skid was poured. The vertical axis is degrees Fahrenheit. The air temperature around the risers in the center of the skid are represented by circles (②). A square (②) represents the outside temperature of the shell at a point 6.5 inches from the base, and a diamond (③) represents the outside temperature of the shell immediately above the rotating band. The peak air temperature was usually reached 22 to 24 minutes after pouring. The maximum air temperature for various shroud designs are shown in Table XVII.

TABLE XVI. SHROUD TEST CONDITIONS

Figure Number	23	24	25	26
Shell Temperature	80	77	80	79
Explosive Temperature	180	1.77	175	176
Wax in Composition B	Sunoco	Petrolite	Petrolite	Petrolite
Test Group	0	Q	Q	Q
Test Number	1	Special	5	4
Skid	2	21	15	1
Date	10/15	10/23	10/23	10/23

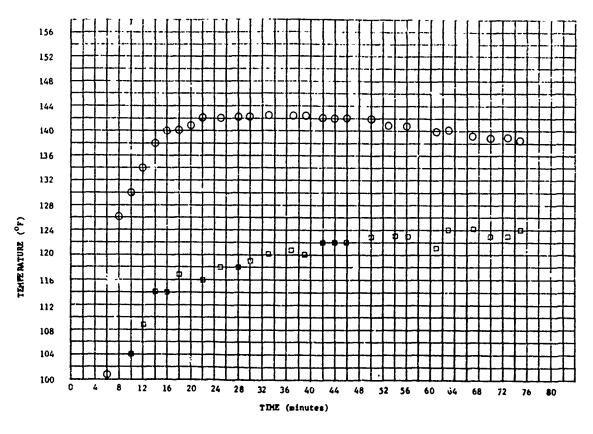


Figure 23. Air Temperature Under Wood Shroud With Baffle Versus Time Curve (Sunoco Wax)

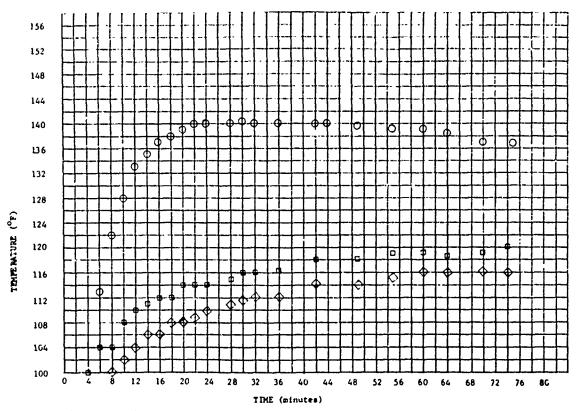


Figure 24. Air Temperature Under Wood Shroud With Baffle Versus Time Curve (Petrolite Wax)

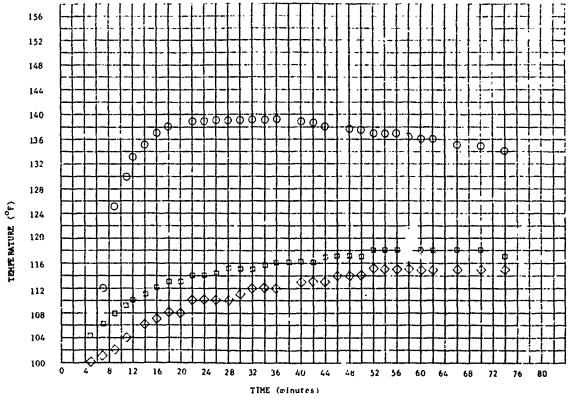


Figure 25. Air Temperature Under Wood Shroud Without Baffle Versus Time Curve (Petrolite Wax)

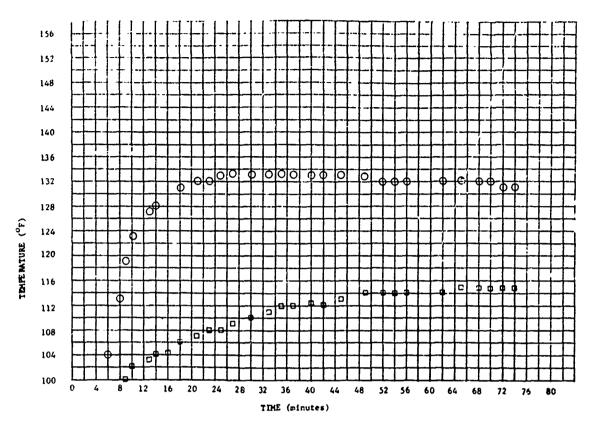


Figure 26. Air Temperature Under Canvas Shroud Versus
Time Curve (Petrolite Wax)

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TABLE XVII. SHROUD MAXIMUM TEMPERATURES

Shroud Design	Shell Temperature Before Pouring	Explosive Temperature Immediately After Pouring	Maximum Air Temperature
Wood Shroud With Baffle	77 80	177 180	140 142
Wood Shroud	80	175	139
Canvas Shroud	79	176	133

The data presented in Table XVII was obtained from Figures 23 through 26. The air temperature under the shroud is also affected by the shell temperature before pouring, and the explosive temperature at time the shell was poured. Thus for a fair comparison, the shell and explosive temperatures should be identical. The conclusion from these tests was that the insulated shroud maintains a higher air temperature.

One series of tests was performed to study the effect of shroud design and cooling bay temperature. The tests were designed so both variables could be studied together. Thus it would be possible to determine if one would affect the other. Table XVIII results show that the wood shroud with baffle produces fewer defects, while the canvas shroud produced the most defects per skid. The reader should keep in mind that these results are from a relatively small number of skids.

TABLE XVIII. SHROUD COMPARISON

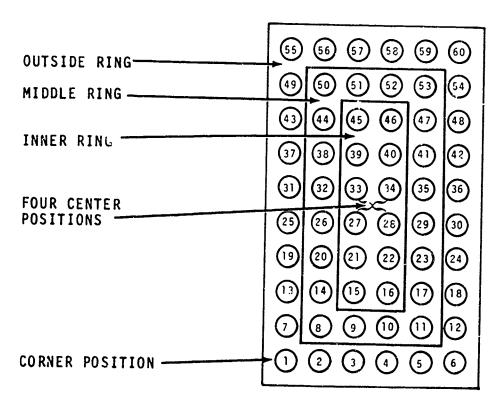
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	Canvas Shroud	Wood Shroud Without Baffle	Wood Shroud With Baffle
Shell Temp (°F)	85-86	85-86	85-86
Explosive Temp (°F)	180-181	180-181	180-181
Number of Skids	8	16	6
No. of Defect Free Skids	5	10	4
Total No. of Defects	7	13	4
Percent Good Skids	62.5	62.5	66.6
Defects Per Skid	0.875	0.812	0.666
Median No. of Defects	2	1	1-2

It was the opinion of the authors that he wood shroud with baffle produced slightly better results chan the canvas shroud under non-ideal conditions. The amount (degree) of improvement was not as significant as originally anticipated, and under ideal conditions in production it may not be worth consideration. However, the wood shroud with baffle does tend to give uniform conditions less subject to extraneous variables such as cooling bay temperature, air movement, or proper placement on the skid. The canvas shroud is subject to variations from each of these conditions. Therefore, the use of wood shroud and baffle or an equally efficient shroud is recommended even though the improvement with respect to defect rate is not statistically significant.

2.10 SHELL POSITION ANALYSIS.

In previous work done by Mr. B.A. Kavanaugh of Joliet AAP, there was some indication that shell location on skid may be a significant factor affecting the production of defective shells. In Mr. B.A. Kavanaugh's analysis, each shell was placed in one of three groups, outside, middle, or center ring. Figure 27 shows the group location on a skid card. The results from Mr. Kavanaugh's first two studies are shown in Table XIX, along with the results of this study. These studies represent unspecified total sample populations but always represent similar skids with 60 identical positions.



HANDLE

Figure 27. Location of Shell Groups On A Skid

TABLE XIX. NUMBER OF DEFECTS PER POSITION BY LOCATION

	No. Shells	B.A.K* Studie	g	Total This		
Location	Per Location	1	2	Study		
Outside Ring	28	7.5	4.0	17.32		
Middle Ring	20	10.0	6.6	20.45		
Inner Ring	12	14.5	6.0	20.58		
Outside Corners	4	5.0	1.75	15.75		
Four Center Positions	4	16.5	7.75	19.25		
Front Half	30	9.4	5.0	18.23		
Back Half	30	10.3	5.5	19.80		
Right Half	30	9.76	5.83	18.93		
Left Half	30	9.96	4.76	19.10		

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*B.A. Kavanaugh

The original assumption was that relative environment of a shell affected the formation of defects. Thus, shells located in the middle ring would have a different environment than shells located in the outside ring, etc. The results of Mr. B.A. Kavanaugh's first two studies indicated that this was an acceptable conclusion; but it did not hold up in later studies. A similar analysis was performed on the data obtained in this study.

Table XIX represents defect frequency by location. As can be seen the corner positions always have a low defect frequency; the center positions have a high defect frequency; and the outside ring has a lower defect frequency than the inner positions. No apparent frequency difference exists when the skid is divided into halves. This is clearly demonstrated by the B.A.K. studies which were conducted on production samples. This study is similar in trend but the significance is masked since some of the skids contained as high as 90% defects.

From Table XIX results, it appeared that shell environment may affect the formation of cavities. However, when each shell position was analyzed separately (Table XX), a different pattern was noted. It was found that certain shell positions had much higher than the average number of defects, while a few others had much lower than the average number of defects. Figure 28 shows the combined total defects from the three studies per shell position. One very interesting observation was that most of the low defect positions were at the handle end of the skid. This is the end which faces the center aisle of the cooling bay. Most of the high defect positions are located in the inside positions on the skid.

The conclusion to be made is that shell position on the skid and possibly the position of the skid in relation to other large objects may affect the cooling rate and hence the formation of defective shells.

It should be noted that there are other factors which could bias the results of these studies. One of these factors is the difference in ambient cooling bay conditions in the summer and winter months. Most of these studies were conducted during the warmer weather and might be different if conducted during the cooler months. Another factor not considered is the possibility that the defect frequencies may relate to multipour position and not skid positions, since the multipours have 50 pouring stations similar in configuration to the skid positions.

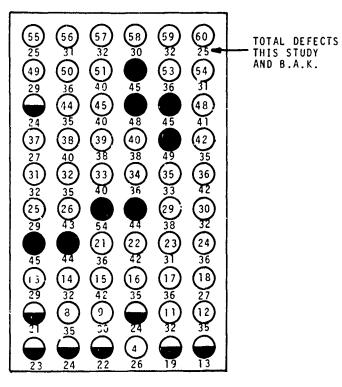
TABLE XX. DEFECT SUMMARY STUDY BY POSITION

Shell Position	This Study	B.A. Stud		Total	Shell Position	This Study	B.A. Stud		Total
1	15	5	3	23	31	15	14	3	32
2	15	6	3	24	32	18	11	6	35
3	13	7	2	22	33	15	17	8	40
4	16	4	6	26	34	17	15	4	36
5	12	6	1	19	35	16	13	4	33
6	11	2	0	13	36	20	9	13	42
7	15	6	0	21	37	12	11	4	27
8	19	14	2	35	38	20	12	8	40
9	19	7	4	30	39	21	11	6	38
10	18	5	1	24	40	21	12	5	38
11	17	8	7	32	41	22	17	10	49
12	19	9	7	35	42	18	13	4	35
13	19	5	5	29	43	17	6	1	24
14	20	8	4	32	44	20	7	8	35
15	24	12	6	42	45	20	16	4	40
16	22	11	2	35	46	22	19	7	48
17	22	7	7	36	47	25	14	6	45
18	12	10	5	27	48	26	11	4	41
19	21	19	5	45	49	22	3	4	29
20	22	15	7	44	50	25	5	6	36
21	19	12	5	36	51	25	8	7	40
22	21	15	6	42	52	24	6	15	45
23	18	5	8	31	53	21	11	4	36
24	22	10	4	36	54	17	7	7	31
25	17	6	6	29	55	20	4	1	25
26 27 28 29 30	20 25 20 18 1.6	13 19 15 13	10 10 9 7 8	43 54 44 38 32	56 57 58 59 60	20 20 17 21 17	8 12 8 5 5	3 0 5 6 3	31 32 30 32 25

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^{*}B.A. Kavanaugh

A COMPLETELY SHADED CIRCLE IN-DICATES THAT THE POSITION WAS ONE OF THE EIGHT HIGHEST WHILE A HALF-SHADED CIRCLE INDICATES ONE OF THE EIGHT LOWEST POSITIONS.



HANDLE

以外,这种种种,我们是一个人,我们们的一个人,也是是一个人,也是一个人,他们们们们们们的,我们们们的一个人,我们是一个人,我们们们们们们们们们们们们们们们们们们

Figure 28. Total Defects Per Position For the Three Studies

2.11 VISCOSITY.

The original theory proposed regarding viscosity was that a high viscosity explosive will entrap more air than a low viscosity explosive during melting, agitation, pouring and the early stages of the cooling process. Since the assumption was made that trapped air caused or helped cause cavities, the logical conclusion was to use a low viscosity explosive and thus maximize the potential for air to escape. The practice of sorting Comp B by box and using only material at 5 seconds viscosity or less had been introduced in the production process at both Joliet and Kansas AAP. the first three weeks of the testing program, sorted low viscosity Comp B was used with a maximum viscosity of 5 sec-Later a series of tests were performed to determine what effect viscosity had on the formation of cavities. tests consisted of pouring 105mm shells with Comp B manufactured with Petrolite wax which had a viscosity of 5 to 7 seconds (high viscosity Petrolite). The results are shown in Table XXI. These results did not demonstrate that viscosity affected the formation of cavities. The hand sorting of Comp B was then terminated in all remaining tests.

TABLE XXI. RESULTS OF SORTED HIGH AND LOW VISCOSITY TESTS

Viscosity

	High	<u>h</u>	Low		
Test	G-1	<u>G-2</u>	E-5	<u>E-6</u>	<u>E-1</u>
Explosive Temperature	174-177	176-177	175-179	175-178	175-177
Steel Temperature	70-78	73-80	69-74	72-75	75-78
Percent Scrap	0	70	0	70	0
Number of Skids	20	10	10	12	11
Total Defects	0	0	0	0	0

Later tests did not produce any data to substantiate the claim that viscosity (up to 7 seconds) affected the formation of cavities in the explosive casts. When the Comp B with Grade B waxes were later used on a regular production basis, the Comp B was used as received without sorting.

2.12 FIBER WASHERS.

,这种是一种,我们是一种,我们是一种,我们是一种,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们就是一个人

Fiber washers approximately 1/16 inch thick were inserted between the riser and the shell. This approach was intended to minimize heat transfer from the funnel to the shell body and to increase the solidification time for the explosive in the neck of the riser. With this accomplished, it would be reasonable to expect fewer cavities to occur at higher (above 79°F) initial shell temperatures. The results of the comparison tests between shells with and without fiber washers are presented in Table XXII. From these results it is obvious that fiber washers do not provide any significant improvement to the process. As a result of these tests, no additional fiber washer tests (with the exception of water cooled skids) were performed.

TABLE XXII. RESULTS OF TEST WITH AND WITHOUT FIBER WASHERS BETWEEN THE RISER AND THE SHELL

	No F	iber	Washe	rs	Fiber Washers						
Shell Temperature	83	82	83	83	82	84	84	85			
Explosive Temperature	179	179	179	179	178	180	179	179			
Defects	8	0	2	3	0	0	0	4			
Shell Temperature	86	89			86	86					
Explosive Temperature	130	180			180	180					
Defects	3	33			3	1					
Shell Temperature	84	84			84	83					
Explosive Temperature	184	184			184	183					
Defects	4	10			7	10					

2.13 BAD LOT PETROLITE.

During the time this test program was being carried out, one of the loading plants commented that they were having difficulties producing acceptable explosive casts using certain lots of Comp B. These lots were dubbed "Bad Lot Petrolite" as Petrolite wax was used in the manufacture of the explosive. The two lots in question were HOL-053-5095 and HOL-053-5137. A series of tests were performed to determine the validity of these claims. The results of these tests are given in Table XXIII.

TABLE XXIII. RESULTS OF BAD LOT PETROLITE TESTS

LOT NO. HOL-053	5095	5095	5095	5137
Test	<u>H-1</u>	<u>H-2</u>	Н-3	<u>N-1</u>
Explosive Temperature	173-178	175-180	175-178	175-177
Steel Temperature	75-78	73-79	72-75	74-76
Percent Scrap	0	40	0	0
Number of Skids	20	20	19	19
Total Defects	1	0	0	0

There was one critical defect produced in test, H-1. Prior to the time this skid was being poured, adverse operating conditions were being experienced due to air and power failures. Due to the nature of the operation it was not feasible to hold the explosive in the system. Since none of the subsequent tests involving "Bad Lot" Petrolite Comp B produced defects, the critical defect was attributed to the adverse operating conditions experienced at the time the skid was poured. Since these results were not any different than previous or later tests in the 72° to 79°F steel temperature, and 173° to 180°F explosive temperature region, it was concluded that the loading difficulties could not be attributed to the explosive.

SECTION III

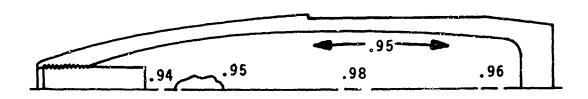
LABORATORY TESTS

3. LABORATORY WORK.

As an adjunct to the process variable studies, sample shells were selected for sectioning to confirm the nature of voids and cavities determined by X-ray and to provide samples for laboratory analysis of the cast Comp B. Laboratory samples were taken from center sections, outside areas of the cast, at the bottom approximately 4 inches below the former intrusion, and just under the former. Samples were analyzed for wax content, RDX content and density. Data analysis is shown in Tables XXIV, XXV and XXVI. An overall summary for samples of Comp B having Petrolite or Indramic wax is shown by Figures 29, 30 and 31.

3.1 WAX CONTENT. (See Figure 29 and Table XXIV).

All samples tested satisfied the minimum wax content of .7% in Comp B. The data cover a wide range of explosive temperature, shell temperature, and varying degrees of wax segregation as visually detectable in the melt kettle, multipour reservoir or in the risers. Thus there is data to show that these factors do not significantly relate to the wax content carried into the cast. The higher wax content in the B sample, center of shell, which is the last area to solidify, is probably the result of wax tendency to segregate as freezing front progresses.



নি ক্রিয়ানি ক্রিয়ান সম্প্রিয়ার সিহায়ের জনক ক্রিয়ান বিশ্বনি হাসন স্থান করি । ১ জান এবং তা এর তা বাব

Figure 29. Wax Analysis (%)

TABLE XXIV. WAX CONTENT

	Top	1 1	. 85	1 1	1 1	1	7	1.00	.97	.73	. 60	1	1		.75		.94	. 83	.83
Riser	Inter- Face	l i	. 99	1 1	1 1	í		.93				1	1			.97	66.		98.
	Bot	1 1	.99	1 1	1 1	ı	.71	1.07	.85	.90	90	1	ı			1.01		.93	88.
	C Top	.93	. 86	.75	1.02	.67	ı	96.	.91	. 79	0	:	ı			.94		88.	.81
Cast	ပ	96.	88.	.73	1.02	.75		.95								1.06		68.	98.
of	В	.99	.93	.83	1.05	.77	.73	1.00	.93	.84	1.01	.97	16,			1.04		86.	16.
Inside	A.	.98	.94	.71	1.02	69•	.70		.91	.94	.92	66.	1.00	.89	.81	1.04		.95	.91
st	U	9 9 3 5	1.00	.74	1.00	. 74	.72	.97	.87	90	.94	ı	ı	ı	ı	ı	1	i	
of Cast	В	1.01	96.	.75	1.00	.73	.73	.91	90	.91	.87	ŧ	ı	į	•	ı	ı	ı	ŧ
Outside	4	.93	.93 98	.73	1.00	.74	.70	. 95	88	.89	.93	ı	ı	ı	ı	ı	i	ı	ı
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	No.	32 55	2 49	19	4 3	56	~	41	47	32	58	09	48	18	48	9	59	7	20
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	Test	H 6	44 rU	0.P 0.P	1 DP	m	Н	က	വ	9	12	14	15	н	7	က	н	ri	22
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3.2 RDX CONTENT. (See Figure 30 and Table XXV).

These data show a slight tendency for RDX to settle at the center of the cast, or the last position to solidify. Figure 30 shows related samples with Indramic wax, for shell with or without a "C" segment cavity. When a cavity does occur, the material just under the former has a lower RDX content than the material around the lower portion of the cavity, and the center of shell is higher in RDX by 2%, compared to a shell without a cavity.

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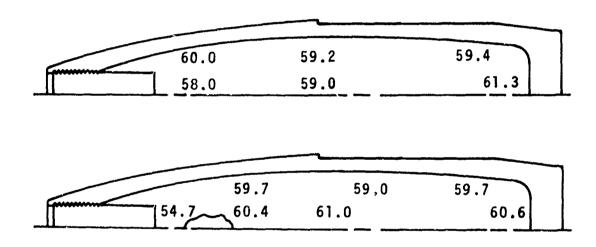


Figure 30. RDX Analysis (%)

TABLE XXV. RDX CONTENT

						•		•						•	8.	•			٠		80.
		Top		i	0	0	62	62	9	62	ı	ı			9			61			58
Riser	Inter-	Face		1	,	7.70	60.7	60.4	58.5	8.09	1	ı		6	59.9	8		60.3	6		56.9
		Bot		ı		ν. •		ф	•	~		ı			58.2	8		56.9	6	,	60.3
		C Top	ι	22.6		ı	س	4.	د	53.1	ı	,		α	55.9	8	! !	57.7	2)	56.5
		ပ		59.9	(رد د	÷	ä	о	60.1	7	_		σ,	61.1	6		59.9	7) 	58.5
100	רבוורבד	В		8.19		•	•	•	•	6.09		•	•	c)	58.7	0	•	9.09	•	•	59.1
		A	1	0.09		٠	•	•	•	60.1		Ł	•	•	60.3		•	0	60.2	•	61.3
400	Parsing	၁	,	0.65			•	•	•	59.5	•	ı		1	ı	1		ı	ı		ı
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		Test		m	•	-4	m	ι.	· (2	12	3.4			-	۱ ۵	יי ו)		- ۱	4	22
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3.3 DENSITY. (See Figure 31 and Table XXVI).

Density data shows a consistent pattern for any of the waxes used. Figure 31 lumps data from a straight single pour process with Indramic, Petrolite and Castor wax. The first areas to solidify, the periphery of the cast, averages 1.70 gm/cc. The center of the cast averages 1.68 gm/cc whether or not a cavity is formed. Density just under the former is 1.63 gm/cc for shell without a cavity, and 1.65 to 1.67 for material around a cavity when one does form. If the cavity is taken into account, the overall density would be less than 1.63 gm/cc. Overall, the data shows that the last portion to solidify has the lowest density, and points up the importance of maximizing capability for mass transfer of the material reservoir in the riser.

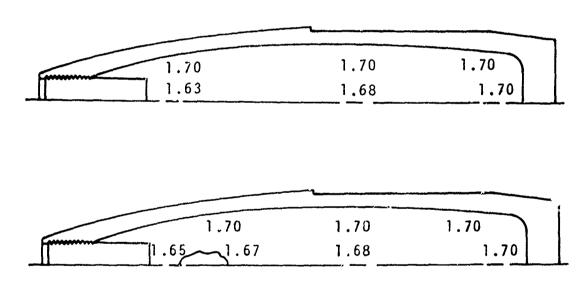


Figure 31. Density Analysis gm/cc

TABLE XXVI. DENSITY

	Top	ומ	1.68	l li	1 1	ı	9	1.70	•		. 7	1 1	•	•	9	1.65	t	1.68	9
Riser	Inter-		1.69	: :	i i	ŧ		1.69		•		j 1	(.69	69.	89	ç	1.69	69
	Bot	1 1	1.68	1 1	1 1	ı	.7	1.69	9	9	9	1 1	ſ	•	9	1.68	V	1.67	1.68
	C Top	1.62	9 -	1.65	1.67	1.64	ı	9•	1.66	۰	9	1 1	U	•	1.66	9	4	1.66	1.67
Cast	ပ	1.61	1.66	1.64	1.69	1.67	9	9	9	۰۰	۰	1.68	4	•	7.66	9	9	1.66	1.68
of	ф	1.67	1.68	1.66	1.70	1.68	9	91		פ ע	٥	1.68	v	•	T . 68	•	9	1.67	1.67
Center	Ą	1.70	1.70	1.70	1.71	1.70		<u>ر</u> ،		• •	• •	1.70	7	• [7.7	. 7	•	1.70	1.70
Cast	ပ	1.73	1.70	1.69	1.70	1.70		1.68	•	•	• 1	1	ı	ĺ	ı	ı	1	ı	1
of	В	1.69	1.69	1.69	1.72	1.71	.7	1.70			• 1	ı	i	1	l	ı	1	1	ı
Outside	A	1.69	1.70	1.71	1.72	1.72	1.70	•	• •	•	. !	ı	i	J	1	;	ı	ı	1
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	No.	32 55	4 6	19	4 3 6 9 9 9	26	rt ç	4.7	32	28	09	4 8	18	48	· ·	•	59	7	20
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3.4 SPLIT PHOTOGRAPHY.

情况就会是"我上面的人,我们也没有不好,我们就是有人的人,我们也没有什么,我们也没有什么,我们也没有什么,我们也是我们的人,我们也没有什么,我们也会会说什么,我 "我们就是我们就是我们的,我们就是我们的人,我们就是我们的人,我们就是我们的人,我们就是我们的人,我们就是我们的人,我们就是我们的人,我们就是我们的人,我们就是

The splits confirm the X-ray films for defects. For shells which do not have a void, an area showing porosity is apparent under the former and is usually detectable in X-ray. There were no instances of base separation noted, and the half-cast cannot be easily removed from the metal part. The splits frequently show "pock marking" around the lower peripheral portion of the cast. These were noted to occur in both cool shell (70-75°F) and hot shell (90°F) and at any explosive pour temperature. The splits from double pour experiments show an interface only at the outer areas where the freezing first occurs. Aside from the pock marks, the only observations of any concern, revealed in a split and not apparent by X-ray, are the cracks and cracking patterns which developed when a water cooling system was used.

SECTION IV

PRODUCTION PROCESS COMMENTS

4. GENERAL.

It is thought desirable at this point to discuss generally the effect of process variables in cast loading of the 105mm Ml shell. As previously demonstrated, the primary variables which must be controlled are shell steel and explosive temperature. The whole cast loading process involves an intricate balance of heat flcw and solidification (crystallization) characteristics of explosive. Any action or variable which effects this in any way inevitably has some effect on the process. Since the mass of the projectiles, and the mass of explosives are the largest mass factors in the system, it is easy to see why they are the prime temperature variable factors which must be controlled. If the remaining variable factors are controlled, it becomes easier to establish the particular range of steel and explosive temperatures required to obtain an optimum cast. Factors, believed to fall in the above category, are delineated below.

4.1 VIRGIN VS SCRAP.

Throughout the entire test program the scrap versus explosive ratio was monitored. Review of the data indicated that casts with scrap (reworked) explosive generally yielded less defects than casts with virgin material. No conclusive evidence for the cause of this was found; however, it is thought that material which has been remelted may contain less trapped air. It would seem prudent to provide for uniform scrap usage in the cast loading process and eliminate this as a process variable in production.

4.2 RISER HEIGHT.

During tests it was noted that defective shells sometimes coincided with "low" riser heights. Several explanations for this have been proposed, none of which is conclusive in itself. The first being that a low riser does not contain a sufficient reservoir of hot material to properly retard cooling in the nose and riser section of the shell. Another reason being a lower riser does not exert sufficient pressure to provide for mass flow into the cooling shell. Again it seems more prudent to assure a full and uniform riser height and eliminate this as a production variable.

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4.3 MULTIPOUR EQUIPMENT FACTORS.

Variable factors peculiar to the individual multipour arrangement include degree of agitation, reservoir level, and the possibility that air is injected into the explosive during cupcharging. Again no conclusive evidence was found linking these variables to defective casts; however, sufficient agitation to assure uniform explosive temperature and to prevent RDX settling in the multipour reservoir should be provided. A constant reservoir level sensing device with automatic feed is desirable. To prevent the agitators from injecting air into explosive during cupcharging, an interlock was installed with the vacuum draw during these loading trials.

4.4 FOREIGN MATERIAL.

Accumulations of wax, lubricant, solidified explosive and other items can build up on various parts of the system and can inadvertently be cast in the shell. If accumulations are sufficient, defective casts can be caused as indicated in Figure 32, which was caused by a glob of wax purposely placed in the cast. Good housekeeping is obviously important.

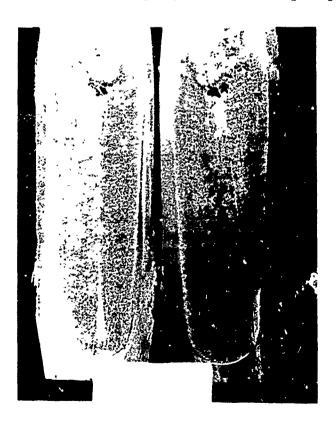


Figure 32. Defect Caused by Glob of Wax

4.5 SHROUD.

The wood shroud with baffle was shown to be slightly more effective than the canvas shroud in the test results. The degree of improvement was not as significant as originally anticipated, and under ideal production conditions may not be necessary. However, the wood shroud with baffle does tend to give uniform conditions less subject to extraneous variables such as cooling bay temperature, air movement, or proper placement on the skid. The canvas shroud is subject to variations from each of these conditions. It is therefore concluded that the use of the more efficient shroud is warranted even though the defect rate between the two shrouds is not statistically significant.

4.6 SKID TEMPERATURE.

The skid used in loading process contains a relatively large mass of steel. In the first stages of test during hotter weather, defects were noted when shell steel temperature exceeded 80°F. During later stages of tests, in cooler weather, a similar level of defects were not noted until shell steel temperature exceeded 83 to 84°F. One possible explanation for this was that the skid was significantly cooler during the later stages of test. From this it is concluded that some control of skid temperature could aid materially in eliminating a process variable.

4.7 PROJECTILE WEIGHT STUDY.

Prior to initiation of this program it was hypothesized that variation in projectile MPTS weight might adversely effect the cast quality of the shell. At the start of this program 500 projectiles were selected from a metal parts lot and the weights were recorded. The projectile weights proved to be fairly uniform and are not considered to be a factor effecting cast quality. Details of the Projectile Weight Study are contailed in Appendix B.

4.8 PRODUCTION SUMMARY.

The first attempts to load Comp B with Grade B wax (Petrolite) in the 105mm Ml projectile at JAAP occurred 4-29 May 1973. During this period 241,847 projectiles were loaded. Frequent and extensive 100% X-ray inspection was required, due to the occurence of "C" segment cavitation defects. A total of 71,587 projectiles required X-ray inspection during this period yielding an apparent production defect rate up to 3%. Loading with Comp B with Grade B wax was discontinued at this point. One additional attempt to load Comp B with Grade B wax was made 6-12 July 1973 with similar unsatisfactory results.

After several weeks of trial loading in early September, it became apparent that projectile MPTS temperature prior to pour and explosive material temperature were the key vari-It was felt that production loading Comp B with Grade B wax could be accomplished by controlling these variables. Accordingly a projectile MPTS temperature of 79°F maximum and an explosive temperature of 176 + 3°F was established as a process control criteria. Additionally, the insulated wooden box shroud was simultaneously implemented into production. Using this production criteria, JAAP has successfully loaded Comp B with Grade B wax (Petrolite, ES 670 and Indramic 170C) since September 1973. Approximately 2 million shells have been loaded through July 74, with 100% X-ray inspections required on only 3 occasions. On two occasions the use of cold shells (a previously known cause for defects during cold months) and on one occasion foreign material were identified as the cause of their defects.

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SECTION V

CONCLUSIONS

conclusions.

The following conclusions are made as a result of this program.

5.1 EXPLOSIVE.

- 1. Comp B using Indramic 170C or Petrolite ES670 Grade B waxes can be used in the 105mm projectile within the limits of projectile (65° to 79°F) and explosive (176° + 3°F) temperatures established by this program. Projectile temperature is the prime consideration.
- 2. Comp B using Sunoco 8810 Grade A wax gives good quality casts over a broader range of process temperatures.

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- 3. The addition of SPAN 85 does not improve the casting properties of Comp B using Indramic or Petrolite wax.
- 4. Comp B using Castor wax (Grade B wax) cannot be used with the same process limits defined for Indramic or Petrolite wax.
- 5. Segregation of Comp B by viscosity (less than 5 seconds and 5 to 7 seconds) was not meaningful. There is no significant effect on cast quality.
- 6. There were no differences noted in the behavior or effect on cast quality of different lots of Comp B using different lots of Petrolite wax.
- 7. The reuse of process scrap can improve cast quality.

5.2 PROCESS.

是一个时间,我们就是一个时间,我们就是一个时间,我们就是一个时间,我们就是一个时间,我们就是一个时间,我们就是一个时间,我们们的时间,这个时间,他们们的时间,他们的时间,他们们的时间,我们们们的时间,我们们们的时间,我们

 Shell temperature is the most significant factor in the use of Comp B with Grade B wax. An upper limit of 79°F is required to avoid "C" segment defects.

- 2. Explosive pour temperature is a significant factor in the production of good explosive casts.
- 3. Shroud type and shroud efficiency are not overriding factors affecting cast quality, but efficient shrouding is considered to be helpful.
- 4. The use of probing, double pouring, or hot topping techniques were not effective process techniques and did not provide a means for reducing "C" segment cavities.
- 5. Forced cooling (water cooling) may be a method of minimizing "C" segment defects, but can cause cracking of the entire cast which is potentially more hazardous and in some cases may not be detectable by X-ray.

5.3 OTHER.

- 1. Projectile weight variations are not an area of concern regarding cast quality.
- 2. Gridding techniques for measuring the projected area of a void of an X-ray were not helpful in interpreting X-rays and defining cavitation criteria.
- 3. Laboratory analyses of cast Comp B from the 105mm Ml shell show data consistent with theoretical analyses of the loading operation.
- 4. Different projectile locations on the skid may give different defect frequencies.

SECTION VI

RECOMMENDATIONS

6. RECOMMENDATIONS.

- 1. It is recommended that provisions be made to cool the projectile metal parts prior to pouring, within the process limits of 65°F to 75°F, for loading operations during the hotter months.
- 2. The use of some form of efficient shroud is recommended in order to minimize variations encountered in the cooling process.
- 3. It is recommended that the processes and materials used in the loading operation be controlled so as to maintain a maximum degree of consistency. It is the opinion of the authors that this is the key which enables successful production operations.
- 4. It is believed that tests on a large scale basis (such as encompassed by this report) are necessary for proving producability of items loaded with Comp B with a newly qualified wax or additive. It is recommended that testing on a similar scale be accomplished when new Comp B waxes or additives are considered for phase-in to production operations.

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APPENDIX A

CAVITATION REQUIREMENTS (MIL-C-45195)

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4. Cavitation Requirements (MIL-C-45195)

Projected Cavities

Cavities with a projected length of 1/32 inch or less will be disregarded. Cavities within the explosive charge will not exceed the requirements specified in Table I.

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	SEGMENT			
TABLE I	A	В	C	Đ
Sum of projected areas of the cavities, excluding pipes, cracks and annular rings, square inch	1/64*	1/4	1/2	1/2
Projected length of any cavity, excluding pipes, cracks and annular rings (in.)	1/8	1/2	1/2	3/4
Fiping cavities, maximum projected area (sq. in.)	0	1/4	1/2	0
Piping cavities, maximum pro- jected width (in.)	0	1/4	1/1,	0
Cracks, maximum projected width (in.)	2ز/1	1/32	1/32	
Annular rings, max. projected width (in.)	0	0	1/4	0

*If the length of the largest cavity is 1/16 inch or less, the maximum total projected area may be 1/20 square inch.

Porous Areas

Porous areas will be treated as cavities and be subject to the same restrictions except that 80% of the projected length and 80% of the projected area will be considered for acceptance purposes.

Cracked Charges

Not more than two transverse cracks will be permitted on any charge, and not more than one transverse crack will be permitted in Segment A. Cracks in Segment D will be disregarded.

Surface Cavitation

Surface cavitation is determined by visual inspection after cavity drilling and cleaning. If a defect is detected by X-Ray in Segment C and is visually detectable as excessive cavitation, it will be marked as such, but not reported as an X-Ray defect.

Cavities formed due to chipped or broken explosive from the sidewalls of the fuze well will not extend in aggregate around more than 1/4 of the circumference. Cavities in the base of the fuze well cavity will not be cause for rejection provided the sum of the areas of the cavities is not greater than 80% of the area of the base and no individual point extends more than 1/4 inch below the maximum depth of the fuze well permitted by the drawing, and provided no point extends above the flat surface on which the liner would rest. Cavities with a maximum dimension of 1/32 inch or less as well as all voids in the area from the top of the shell down three inches into the fuze well will be disregarded.

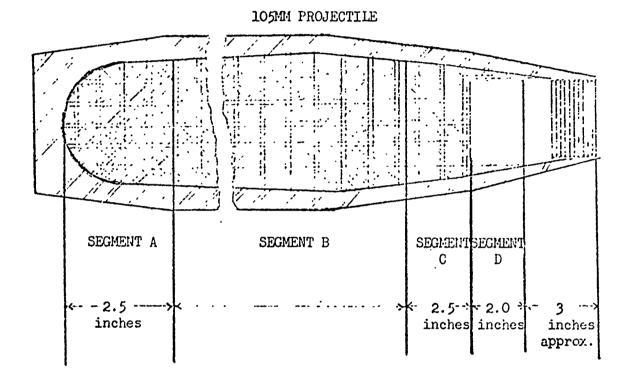
5. Cavitation Defects

Critical Defects:

Code No.	<u>Defect</u>
14001	Cavitation, cracks or annular rings in Segment A in excess of that permitted in Table I.
14002	Cavitation, cracks or annular rings in Segment B, C, or D in excess of twice that permitted in Table I.
14003	Cracks in excess of that permitted under cracked charges above.
14004	Base separation. There shall be no separation between the shell base and the charge. In the event an original x-ray picture leaves doubt as to acceptability, the cartridge shall be re-x-rayed at an angle 90° from that of the original exposure and in the same plane.

Minor Defect:

Cavitation, cracks or annular rings in Segment B, C, or D in excess of that permitted by Table I, but not more than twice that permitted by Table I.



APPENDIX B

PROJECTILE WEIGHT STUDY

PALLET //1 PROJECTILE LOT NO. NPK 1-765

				•
1.	25.83	21. 25.89	41. 25.86	61. 25.84
2	. 25.92	22. 25.90	42. 25.95	62. 25.86
3	. 25.94	23. 25.82	43. 25.87	63. 25.85
4	25.87	24. 25.85	44. 25.95	64. 25.89
5.	25.90	25. 25.88	45. 25.84	65. 25.87
6.	25.93	26. 25.93	46. 25.87	66. 25.86
7.	25.88	27. 25.89	47. 25.85	67. 25.91
8.	25.81	28. 25.86	48. 25.93	68. 25.82
9.	25.93	29. 25.91	49. 25.89	69. 25.94
10.	25.93	30. 25.87	50. 25.89	70. 25.92
11.	25.93	31. 25.93	51. 25.94	71. 25.85
12.	25.87	32. 25.89	52. 25.89	72. 25.94
13.	25.88	33. 25.85	53. 25.95	73. 25.92
14.	25.90	34. 25.86	54. 25.93	74. 25.90
15.	25.85	35. 25.96	55. 25.87	75. 25.84
16.	25.86	36. 25.86	56. 25.89	
17.	25.94	37. 25.87	57. 25.96	
18.	25.82	38. 25.88	58. 25.95	•
19.	25.87	39. 25.82	59. 25.93	• -
20.	25.88	40. 25.89	60. 25.92	
				80. 25.85

PALLET #2 PROJECTILE LOT NO. NPK 1-765

1.	25.93	21.	25.90	41.	25.89	61.	25.84
2.	25.91	22.	25.82	42.	25.82	62.	25.92
3.	25.89	23.	25.80	43.	25.87	63.	25.87
4.	25.87	24.	25.87	44.	25.84	64.	25.90
5.	25.89	25.	25.83	45.	25.92	65.	25.88
6.	25.91	26.	25.88	46.	25.89	66.	25.89
7.	25.89	27.	25.96	47.	25.87	67.	25.94
8.	25.83	28.	25.87	48.	25.90	68.	25.89
9.	25.86	29.	25.88	49.	25.89	69.	25.82
10.	25.90	30.	25.93	50.	25.83	70.	25.86
11.	25.79	31.	25.91	51.	25.85	71.	25.92
12.	25.88	32.	25.81	52.	25.91	72.	25.87
13.	25.77	33.	25.82	53.	25.86	73.	25.87
14.	25.84	34.	25.84	54.	25.89	74.	25.84
15.	25.90	35.	25.90	55.	25.89	75.	25.86
16.	25.88	36.	25.88	56.	25.86	76.	25.79
17.	25.90	37.	25.88	57.	25.91	77.	25.95
18.	25.86	38.	25.89	58.	25.94	78.	25.84
19.	25.88	39.	25.85	59.	25.83	79.	25.87
20.	25.90	40.	25.87	60.	25.84	80.	25.93

PALLET # 3 PROJECTILE LOT NO. NPK 1-765

1.	25.76	21.	25.89	41.	25.83	61.	25.89
2.	25.87	22.	25.89	42.	25.85	62.	25.92
3.	25.87	23.	25.82	43.	25.83	63.	25.93
4.	25.85	24.	25.83	44.	25.89	64.	25.81
5.	25.88	25.	25.88	45.	25.84	65.	25.84
6.	25.91	26.	25.85	46.	25.89	66.	25.86
7.	25.87	27.	25.92	47.	25.82	67.	25.93
8.	25.79	28.	25.86	48.	25.94	68.	25.81
9.	25.89	29.	25.84	49.	25.85	69.	25.84
10.	25.95	30.	25.86	50.	25.89	70.	25. 83
11.	25.91	31.	25.90	51.	25.84	71.	25.87
12.	25.89	32.	25.86	52.	25.92	72.	25.86
13.	25.90	33.	25.83	53.	25.91	73.	25.87
14.	25.83	34.	25.90	54.	25.89	74.	25.83
15.	25.77	35.	25.84	55.	25.83	75.	25.85
16.	25.82	36.	25.90	56.	25.83	76.	25.93
17.	25.93	37.	25.86	57.	25.90	77.	25.84
18.	25.81	38.	25.90	58.	25.86	78.	25.88
19.	25.97	39.	25.89	59.	25.80	79.	25.82
20.	25.85	40.	25.80	60.	25.89	80.	25.82

PALLET # 4 PROJECTILE LOT NO. NPK 1-765

1.	25.83	21.	25.89	41.	25.93	61.	25.82
2.	25.87	22.	25.83	42.	25.85	62.	25.87
3.	25.85	23.	25.82	43.	25.92	63.	25.95
4.	25.92	24.	25.85	44.	25.89	64.	25.90
5.	25.87	25.	25.87	45.	25.83	65.	25.96
6.	25.83	26.	25.86	46.	25.87	66.	25.79
7.	25.89	27.	25.77	47.	25.85	67.	25.87
8.	25.82	28.	25.84	48.	25.90	68.	25.85
9.	25.89	29.	25.88	49.	25.90	69.	25.93
10.	25.90	30.	25.84	50.	25.86	70.	25.82
11.	25.85	31.	25.90	51.	25.91	71.	25.86
12.	25.89	32.	25.91	52.	25.89	72.	25.81
13.	25.89	33.	25.84	53.	25.84	73.	25.91
14.	25.94	34.	25.88	54.	25.92	74.	25.92
15.	25.94	35.	25.82	55.	25.90	75.	25.79
16.	25.89	36.	25.89	56.	25.79	76.	25.88
17.	25.91	37.	25.86	57.	25.74	77.	25.87
18.	25.74	38.	25.88	58.	25.85	78.	25.89
19.	25.89	39.	25.96	59.	25.74	79.	25.89
20.	25.84	40.	25.81	60.	25.93	80.	25.87

PALLET // 5 PROJECTILE LOT NO. NPK 1-765

	l.	25.85	21.	25.94	41.	25.85	61.	25.80
	2.	25.92	22,	25.91	42.	25.87	62.	25.90
	3.	25.88	23.	25.89	43.	25.79	63.	25.87
	4.	25.91	24.	25.83	44.	25.96	64.	25.81
	5.	25.88	25.	25.98	45.	25.93	65.	25.84
	6.	25.89	26.	25.90	46.	25.92	66.	25.86
	7.	25.78	27.	25.96	47.	25.85	67.	25.83
	8.	25.85	28.	25.91	48.	25.81	68.	25.87
	9•	25.89	29.	25.80	. 49.	25.89	69.	25.90
1.	0.	25.89	30.	25.86	50.	25.92	70.	25.89
1	1.	25.91	31.	25.93	51.	25.93	71.	25.90
1	2.	25.92	32.	25.81	52.	25.83	72.	25.82
1	3.	25.86	33.	25.9/4	<i>5</i> 3.	25.91	73.	25.81
1.	4•	25.99	34.	25.91	54.	25.83	74.	25.82
1	5.	25.92	35.	25.86	55.	25.95	75.	25.90
16	·	25.89	36.	25.81	56.	25.88	76.	25.95
17	' •	25.86	37.	25.93	<i>5</i> 7.	25.90	77.	25.87
1.8		25.87	38.	25.92	58.	25.89	78.	25.86
19	•	25.85	39.	25.95	59.	25.93	79.	25.90
20	•	25.90	40.	25.37		25.85	80.	25.89
		•				-	-0.	~/•07

PALLET # 6 PROJECTILE LOT NO. NPK 1-765

1.	25.90	21.	25.81	41.	25.89	61.	25.91
2,	25.85	22.	25.81	42.	25.85	62.	25.87
3.	25.91	23.	25.88	43.	25.87	63.	25.83
4.	25.82	24.	25.92	44.	25.90	64.	25.84
5.	25.89	25.	25.90	45.	25.89	65.	25.90
6.	25.79	26.	25.89	46.	25.90	66.	25.91
7.	25.86	27.	25,96	47.	25.86	67.	25.95
8.	25.92	28.	25.88	48.	25.95	68.	25.96
9.	25.81	29.	25.93	49.	25.91	69.	25.89
10.	25.89	30.	25.94	50.	25.84	70.	25.95
11.	25.82	31.	25.87	51.	25.86	71.	25.87
12.	25.91	32.	25.87	52.	25.87	72.	25.93
13.	25.91	33.	25.90	53.	25.86	73.	25.92
14.	25.89	34.	25.91	54.	25.88	74.	25.80
15.	25.85	35.	25.93	<i>55</i> .	25.86	75.	25.80
16.	25.86	36.	25.83	56.	25.86	76.	25.90
17.	25.85	37.	25.89	57.	25.93	77.	25.84
18.	25.93	38.	25.81	58.	25.86	78.	25.97
19.	25.89	39.	25.86	59.	25.87	79.	25.94
20.	25.87	40.	25.86	60.	25.91	80.	25.95

PALLET # 7 PROJECTILE LOT NO. NPK 1-765

1. 25.84

11. 25.97

2. 25.81

12. 25.88

3. 25.93

13. 25.87

4. 25.89

14. 25.88

5. 25.82

15. 25.83

6. 25.76

16. 25.85

7. 25.84

17. 25.84

8. 25.85

18. 25.93

9. 25.92

19. 25.92

10. 25.83

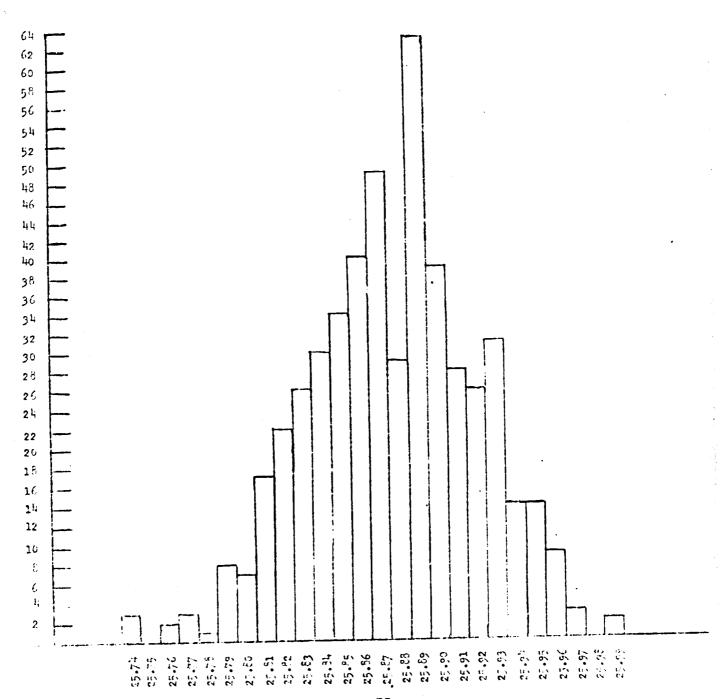
20. 25.84

 High
 25.99

 Low
 25.74

 Average
 25.87634

 Standard Deviation
 0.04393



APPENDIX C

PHYSICAL PROPERTY DATA

COMPOSITION B PHYSICAL PROPERTY DATA

HEAT OF FUSION:

8.0 ca1/gm

THERMAL CONDUCTIVITY:

6.2 X 10 cal/sec-cm 0°C.

COEFFICIENT OF EXPANSION:

Linear

ooc.

Length/unit length - 0°C.

-60° to 0°

5.31 X 10⁻⁵

0° to 70°

6.26 X 10⁻⁵

Volume:

4% shrinkage upon solidification

SPECIF. HEAT:

Ooc.

Cal/gm/°C.

50

0.365

75

0.376

85

0.354

90

0.341

100

0.312

DENS ITY:

1.65

MELTING POINT:

78-80°C.

APPROXIMATE WEIGHT OF THE EXPLOSIVE CAST:

REFERENCES:

a) Engineering Design Handbook AMCP 706-177

b) JANAF Fuze Committee, Journal Article, Volume 1, August 1970. Published by Picatinny Arsenal

PHYSICAL DATA ON 105MM HE SHELL

WEIGHT EMPTY"

25.9 lbs.

SPECIFIC HEAT @20°C

0.1075 Cal/gm/°C

THERMAL CONDUCTIVITY:

0.17 Cal/sec/sq.cm./°C/cm

MATERIAL OF CONSTRUCTION: Nonresulphurized carbon steel

APPENDIX D

TEST DATA

DEFINITION OF SAMPLE POINTS AND RESULTS

A. <u>Multipour Data</u>

- Reservoir Temperature -- is the temperature blend of the water as it leaves the multipour reservoir jacket sections. The temperature is obtained from a 24 hour recorder-controller and is noted at the time the skid is poured. (Marked in 2°F increments.)
- 2. Cup Temperature -- is the temperature blend of the water as it leaves the multipour cup jacket sections. The temperature is obtained from a 24 hour recorder-controller and is noted at the time the skid is poured. (Marked in 2°F increments.)
- 3. Material Temperature -- in a single pour skid this is the material temperature on the top of the riser after the skid is poured. On skids which receive two distinct pours the material temperature for the first pour is the material temperature in the reservoir just prior to filling the cups. The second pour material temperature is the material temperature in the top of the riser immediately after pouring. In all cases the temperature is obtained by using a dial thermometer marked in 2°F increments.

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- 4. Shell Temperature -- is the temperature of the shell measured in the upper bourrelet using a pyrometer. (Marked in 5°F increments.)
- Time Poured -- is the time of day at which the skid was poured.
- 6. Duration of Pour -- is the time required to pour the shells. The time interval starts when the valves at the bottom of the cups are opened and ends when the valves are closed.
- 7. Multipour Number -- is the pouring bay number in which the skid was poured.

B. Core Melting Data

- 1. Time Start -- is the time the probe started down.
- Time Probe Down -- is the time the probe reached its prescribed depth.
- 3. Time Finish -- is the time the probe starts to leave the shell.
- 4. Probe Temperature -- is the average temperature of the probe as determined in the field.
- 5. Probe Steam Pressure -- is the pressure of the steam supply to the probes.
- 6. Core Melt Number -- is the unit number of the come melt used.

C. Cooling Bay Data

- Cooling Bay Position -- is the cooling bay in which the skid was placed to cool, followed by the location in the bay in which the skid was placed. Each cooling bay holds 14 skids.
- Length of Shroud Time -- is the length of time after the skid is poured when the shroud is to be removed. The time is given in minutes.
- 3. Cooling Bay Temperature Averages -- this is the average of three temperatures taken at the stated locations. The temperatures are recorded at the following times:
 - When the skid reaches its destination in the cooling bay.
 - b. When the shroud is removed.
 - c. At the end of the cooling period which is 3.75 hours after the skid is poured.

The temperatures are recorded at the following locations within the bay:

Α	Between	Skid	Locations	ß	and	9
В	"	11	**	12	11	13
С	11	11	**	1	11	2
D	11	11	11	6	11	7
Bay	t1	**	11	4	11	5

A, B, C, and D are located 2.5 feet from the floor and 2 to 2.5 feet from the wall. The bay temperature is measured at a point 5.5 feet from the floor and 1 foot from the wall.

D. X-Ray Results

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- Number of Shells Poured -- is the actual number of acceptable shells poured. Any shell in which the Composition B level is not within 1.5 inch of the top of the riser will be deleted from the test. Any shell which received abnormal treatment which can cause a cavity will also be deleted from the test, such as probing with a cold probe before the Composition B is solidified.
- 2. Number of Criticals -- is the number of critical shells on the skid as defined in Item 11.
- 3. Number of minors -- is the number of minor shells on the skid as defined in Item 11.
- 4. Number of Cavities -- the number of shells with cavities.
- 5. Number of Good Shells -- the number of shells poured minus the number of criticals and minors.

D. X-rey Results contd.

- 6. Maximum Area of Cavity -- the maximum cavity area of any shell on the skid.
- Average Area of Cavity -- total cavity area for the skid divided by the number of shells with cavities.
- 8. Median Area of Cavity -- is the middle observation of area in the list of areas when ordered from largest to smallest.
- Total Area of Cavity -- is the sum of the area of all cavities on the skid.
- 10. Area -- is the number of full blocks plus the one half of the number of partial blocks covered by the cavity. Each block is 0.1 inch by 0.1 inch.

ll. Critical Defects:

Defect

- A Cavitation, cracks or annular rings in Segment A in excess of that permitted in Table I.
- B Cavitation, cracks or annular rings in Segment B, C, cr D in excess of twice that permitted in Table 1.
- C Cracks in excess of that permitted under <u>cracked</u> <u>charges</u> above.
- D Base separation. There shall be no separation between the shell base and the charge. In the event an original X-ray picture leaves doubt as to acceptability, the cartridge shall be re-X-rayed at an angle 90° from that of the original exposure and in the same plane.

Minor Defect: Cavitation, cracks or annular rings in Segment B, C, or D in excess of that permitted by Table I, but not more than twice that permitted by Table I.

D. X-Ray Results contd.

TAPLE I

		Segment		
	A	В	С	D
Sum of projected areas of the cavities excluding pipes, cracks and annular rings, square inch	1/64*	1/4	1/2	1/2
Projected length of any cavity, excluding pipes, cracks and annular rings (in.).	1/8	1/2	1/2	3/4
Piping cavities, maximum projected area (sq. in.)	0	1/4	1/2	0
Piping cavities, maximum projected width (in.)	0	1/4	1/4	0
Cracks, maximum projected width (in.)	1/32	1/32	1/32	-
Annular rings, max. projected width (in.)	0	0	1/4	0

*If the length of the largest cavity is 1/16 inch or less, the maximum total projected area may be 1/20 square inch.

NOTE:

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All cavities in this report are C segment cavities appearing just under the former. No other defects were found except that a "stringer" from C segment will sometimes extend into B segment.

		Ite	itte.	ite	ite	ite	ite	ite	tte	tte	ite	te	ite	ite	tre	1te	itte.	itte	ite	1116	ite	ite	Ite	-057-1	-057-1	.057-1	-057-1	.057-1	lite	lite	ite	lite	lite	Lite	~	~	~	~	~	~	lite	lite
	B G	Petrolite	Pecrolite			Petrolite	Petrolite	Petrolite	Petrolite		Petrolite	Petrolite	Petrolite	Petrolite	n HOL.	an HOL·	n HOL-	Span HOL-057-1	ın HOL.	Petrolite				Petrolite	Petrolite	057-	057-	HOL-057-3	HOL-057-3	057-	057-	/ Petr	, Petro									
	Wax Used in Comp B	viscosity	viscosity	Low viscosity	Low viscosity	Petrolite with Span HOL-057-1	Petrolite with Span HOL-057-1		Lth Spe	Petrolite with Span HOL-057-1	Low viscosity	viscosity	viscosity	viscosity	viscosity	Low viscosity	Castor Wax HOL-057-3			Wax HO	Castor Wax HOL-057-3	Castor Wax HOL-057-3	High viscosity Petrolite	High viscosity Petrolite																		
	x Used	Low visa	Low vis	Low vis	Low vis					LOW VIB			Low vis			Low wise	Low vis	Low vis	LOW VIS	Low vis	Low vis	OW VIB	ow vis	lite w	lite w	lite w	Petrolite with	ite w	OW V18	Low vis		Low vis	Low vis	ow vis	astor 1	astor 1	Castor Wax	Castor Wax	astor	astor	igh vi	igh vi
		Ä	À	٦	À	Ā	ŗ	À	Ā	Ċ.	Ā	À	Ä	Ľ.	Ĺ,	Ä	À	ħ	دَ	À			-	Petro	Petro	Petro	Petro	Petrc		ר		.	-1	_	O	Ċ	O	Ü	ပ	ပ	X	æ
	Notes		-	-		-	-			-	-	-	1,2	1,3	1,2	1,3	_	-		-	1,4	1,4	1,4,						~			-4	-	٦,							9	9
Two Increment	Pouring																				yes	Ses.	yes																			
	ĺ																						ñ																			
Probe	Time																s	S	2.5	2.5	2	2.5	In-Out			2.5	2.5	2.5		2.5		2.5										
Probe	Depth																1-2	1-2	1-2	12	1-2	1-2	1-2			1-2	1-2	1-2		1-2		1-2										
Percent	Scrap	0	0	0	0	0	0	0	0	0	07	70	07	0,	70	07	40	70	07	40	70	40	40	0	70	40	0	20	0	0	07	40	0	55	o	0	0	0	40	40	0	20
e1	ature	78	75	77	87	82	80	93	92	93	85	85	84	80	80	82	82	80	82	80	81	81	80	78	79	78	75	79	.78	78	71	74	.74	75	74	95	93	70	70	70	82	80
Steel	Temperature	70-78	69-75	70-11	80-87	80-82	Φ.	90-93	90-92	92-93	77-85	82-85	80-84	æ	æ	80-82	79-82	79-80	80-82	77-80	σ.	80-81	œ	74-78	75-79	75-78	77-73	74-79	75-78	75-78	70-71	68-74	69-74	72-75	69-74	92-95	90-93	_	_	_	70-78	73-80
ial	ture	74	80	.85	9/	6/	.85	9	.82	.84	.76	82	78	84	85	7	78	98	77.	80	77	78	.78	78	78	77	78	78	111	178	9/	11	179	178	.79	9/.	84	.87	80	76	.77	77
Material	Temperatura	172-174	179-180	182-185	175-176	177-179	181-185	176	180-182	183-184	173-176	180-182	176-178	178-184	183-185	184	176-178	180-186	176-177	178-180	176-177	177-178	176-178	174-178	176-178	176-177	176-178	176-178	175-177	175-178	175-176	175-177	175-179	175-178	176-179	174-176	182-184	185-187	177-180	175-176	174-177	176-177
Number	of Skids	•	•	•	2	à	- 31	•	.	•	60	æ	₹.	•	•	•	•	-	•	J.	•	-37	•	0	0	0	0	_	-1	٥	0		0	7	•	•	•	4	'n	2	0	0
ž	ŀ	7	•	•		•	•	•	•	•	~	~	•	•	•	7	,	•	•	•	7	•	•	7	Ã	Ä	Ä		11	Ä	Ä	-	Ã	<u>ن</u> ــــ	•	•	-	•	•	•	~	Ā
Tean	Number	-4	2	m	4	2	•	7	œ	6	2	11		7	٣	4	-	7	က	4	5	φ.	7	-	7	က	7	ς,	-	7	٣	4	'n	9		7	m	4	Ś	œ	-	7
Test	Group	<	<	٠	<	<	<	<	<	<	<	⋖	Д	æ	м	Д	U	U	ပ	ပ	U	ပ	ပ	Ð	Ω	Ω	Ð	A	M	м	ш	មោ	ш	ы	ĹŁ,	ţri	Es, I	استا	i., 1	ja , (<u>.</u>	ဗ

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是是一个人,这个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们

Wax Used in Comp B	Petrolite HOL-053-5095	11te HOL-053-5095	1te HOL-053-5095	Castor wax HOL-057-3	Castor Wax HOL-057-3	Castor wax HOL-057-3	: wax HOL-057-3	Castor wax HOL-057-3	Indramic wax	Indramic wax	nic wax	ofc wax	nic wax		nic wax		ofx wex	nic wax	nic wax	ofc wax	nic wax	nic wax	nic wax	nic wax	nic wax	ofc wax	nic wax	ofc wax													
Wax Us	Petrol	Petrolite	Petrolite	Castor	Castor	Castor	Castor	Castor	Indran	Indran	Indramic	Indremix	Indramic	Indramic	Indramic	Indramic	Indramic	Indramic	Indramic	Indramic	Indramic	Indramic	Indramic																		
Notes																																	_	∞	0	,	2		2	2:	01
Two Increment Pouring																																	yes	yes	yes						
Probe Time													2.5	In-Out	2.5	In-Out			2.5	5.0									,	S	51										
Probe Depth													3.5	3.5	1.5	1.5			3.5	3.5										4	7										
Percent Scrap	c	07	0	0	70	70	0	20	0	0	0	0	07	07	07	0*-0	70	07	40	07	07	0	20	07	0+	07	70	07	70~100	07	40	40	07	07	70	40	40	07	40	70	07
Steel Temperature	7578	73-79	72-75	78-81	77-79	73-78	74-75	74-75	71-72	92-93	76-06	70-73	81-83	81-83	82-83	83-84	82-83	77-79	90-95	90-92	8	75-77	75-78	75-77	75-78	82-85	26-78	82-85	76-80	89-91	89-90	8	90-91	8	90-91	82-83	82-85	86-89	98	83-84	78
Material Temperature	173-178	175-180	175-178	175-177	174-178	175-182	175-177	176-177	175-176	175-176	187-189	183-186	180-184	182	183-184	184	181-183	175-176	174-175	176-178	175-177	176-178	175-178	176-179	179-181	180	182-184	184-186	177-180	180	179-180	179-182	179-180	180	130-162	179	178-180	180	180	183-184	184
Number of Skids	20	2 2	61	10	10	21	10	7	7	7	4	Q	7	7	7	4	7	10	4	4	2	01	10	17	ۍ	٠	9	9	11	4	4	7	ო	ო	ო	7	7	7	7	7	7
Test Number		• ~	1 (~		7	٣	4	5	-	7	က	7	5	9	7	œ	σ.	10	11	12	13	14	15	16	17	18	19	20	21	21	22	23	-	2	e	-	7	٣	7	ν,	9
roup	=	: =	: =	; H	H	1	H	-	ר	ה	ŗ	~)	ה	ה	ר	٦	2	רי	7	ר	•	2	ר	ר	٦	٦	ה	.	: רי	×	×	×	Ļ	H	⊷ 1	X	Σ	Σ	X:	Σ;	£,

THE SECTION OF THE PROPERTY OF

Wax Used in Comp B	Petrolite HOL-053-5137	Sunoco wax	Sunoco wax	Sunoco wax	Sunoco wax	span	Indramic with span HOL-057-2	3pan	Indramic with span HOL-057-2	Petrolite															
Notes										13	11		11	12	=	12	11	12		12		12	12		
Two Increment Pouring																									
Probe Time																									
Probe Depth																									
Percent Scrap	0	0	0	0	0	0	0	0	0	07	40	40	40	40	40	07	40	07	40	07	40	07	70	07	07
Steel Tempe rature	74-76	80	90-95	96-06	80-61	75-76	85-86	84-85	75-76	79-81	81-82	89-82	-9-81	80-83	85-86	85-37	85-86	85-86	84-87	85-87	84-86	85-86	2	60-64	70-76
Material Temperature	175-177	180	179-180	184-185	182-184	176	176-177	184-185	184-185	183-182	179-180	180-181	175-177	174-177	179-182	180-181	180-181	180-181	180-182	180-182	180-181	180-182	176-177	175-177	176
Number of Skids	19	4	7	7	7	Ŋ	٧	וט	٧	S	5	Ŋ	10	10	v	Ŋ	'n	ะา	'n	۰.	Ŋ	٧.	10	ş	10
Test Number		-	7	m	4	_	· (1	٣	7		7	m	- 7	S	•	7	80	6	10	11	12	13	14	15	16
Test	z	0	0	0	0	ρ,	Δ,	Δ.	۵.	0	· 0	0	0	0	0	0	.0	· 0	0	•	′ ⊃	· 0	, o	0	· ~

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| Marie Ma

NOTES:

- 1. Sorted low viscosity Composition B was used. The viscosity was 5 seconds or less. Lot HOL-053-5050.
- 2. First pour was 176°F with a second pour of 200°F. Height of first pour was to the top of the former.
- 3. First pour was 176°F with a second pour of 200°F. Height of first pour was 3/4 of the way up the former or 3 3/4 inches from the bottom of the riser.
- 4. The first increment was poured to 3 3/4 inches from the bottom of the riser. The second pour material temperature was 200°F.
- 5. There was no 5+1 minute delay between pouring and probing. These skids were probed as soon as they reached the cooling bay.
- 6. Sorted high viscosity Composition B was used. The viscosity of 6 seconds or higher.
- 7. One half of the explosive was poured in the first increment. There was a time delay of 1 minute between pours.
- 8. One half of the explosive was poured in the first increment. Then there was a time delay of 2 minutes between pours.
- One half of the explosive was poured in the first increment.
 There was a time delay of 3 minutes between pours.
- 10. Fiber washers were placed between the riser and shell.
- 11. Canvas shroud was used.
- 12. Picatinny shroud without the baffle was used.
- 13. Picatinny shroud with modified baffle was used. The center section of the baffle was removed.

GROUP A - ST AIGHT POURING

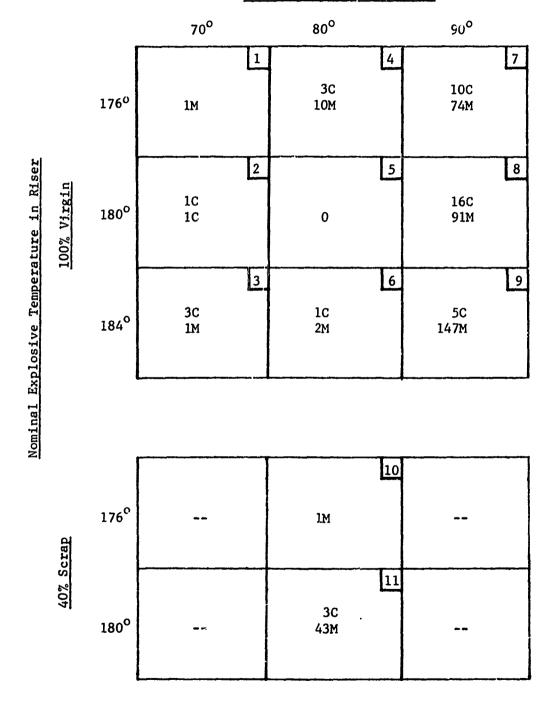
Test #	Explosive Temperature, OF*	Shell on Temperature, F*
1	176	70
2	180	70
3	184	70
4	176	80
5	180	80
6	184	80
7	176	90
8	180	90
9	184	90
10	176	80
11	180	80

NOTES:

- * Nominal Temperature record the actual temperature.
- 1. The riser temperature will be the same as the shell temperature.
- 2. Tests 1 thru 9 will use all virgin material. Tests 10 and 11 will use 40% scrap.
- 3. Single pour all shells.
- 4. Shroud time 1.25 hours.
- 5. Cooling period 3.75 hours.
- 6. 100% X-ray all shells.
- 7. Use wood shroud.
- 8. Use Composition B containing Petrolite ES670 wax which has been sorted by viscosity. The maximum viscosity will be 5 seconds.

GROUP A DEFECT SUMMARY

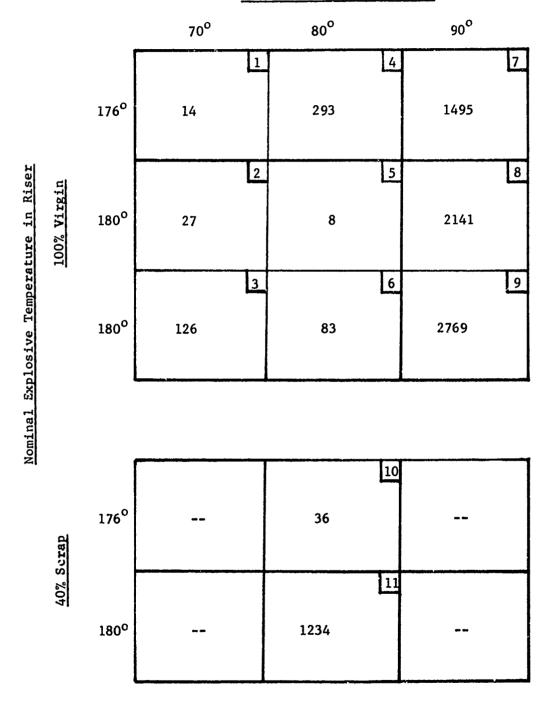
Nominal Shell Temperature



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GROUP A GRIDDING SUMMARY

Nominal Shell Temperature



TEST CROUP A

Test Eurber	-	-	1	-	
Date 8/27	8/:7/73	8/27/75 8/27/73 8/27/73 8/27/73	8/27/73	8/27/73	
Skid Mumber	6	10	11	12	

Hultipour Data (First Pour)

Reservoir Temperature	176	176	178	178	
Cup Temperature	178	178	179	179	
Material Temperature	174	173	172	174	
Shell Temperature	78	12	7.3	70	
Time Poured	9:18	9:23	9:30	9.35	
Duration of Pour	59	43	35	70	
Multipour Number	2	3	č	٠,	

tipour Data (Second Pour)

	(man annual page madea min				-
Reservoir Temperature	•	٠	-	-	
Cup Temporatura	•	•	•	•	
Muterial Terperature	•	•	•	•	
Time Poured	•	•		,	
Garation of Pour	•	•	•	•	
Multipour Number	•	•	•	•	

Core Melting Data

Tize Start					
Down		, t	•		
fine Finish	- · .!	-		-	
Duration of Pour		•			
rature				•	
Probe 1: 1 Minters		•	-	•	

TEST GROUP A

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Test Number	1	1	-	1	
Date	B/27/73 B	8/27/73 8/27/73 8/27/73	8/27/73	8/27/73	
Skid Number	9	10	11	71	

Cooling Bay Data

Cooling Bay - Fesition	6•€	01-6	3-11	3-11 3-17	
Length of Shroud Time	25	25	2,5	51	
Cooling Bay Temp. Averages					
٧					
æ					
Ç					
Q					
Вау	8	96	95	%	

Number of Shells Powred	60	09	99	9	
Number of Criticais	5	0	0	0	
Number of Minors	o	3	1	0	
Number of Cavities	0	o	1	0	
Number of Good Shells	09	09	65	09	
Maximum Area of Cavity	э	o	0.41	0	
Average Area of Cavity	5	0	14.0	0	
Median Area of Cavity	•	•		•	
Total Ames of Cavity	0	٥	14.0	0	

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Test Member	٠,	2	^,	3	
Date	8/28/73	8/28/73 8/28/73 8/-8/73 8/-8/73	8/78/73	8, -8, 73	
Skid Number	6	01	11	:	

	Multipo	ur Data (Multipour Data (First Pour)	,	
Reservoir Temperature	184	781	184	781	
Cup Temperature	184	781	184	184	
Material Temperature	180	180	621	081	
Shell Temperature	7.5	2	02	54	
Time Poured	8:38	8:42	8:47	8.53	
Duration of Pour	17	42	1,2	0,7	
Multipour Number	2	7	r	2	

	ed ta my	surribour vata (second four)	second ro	Į.	
Reservoir Temperature	•	•	ŀ	·	
Cup Temperature	•	•	,		
Material Temperature	•		,		
Time Powred .		1			
Duration of Pour					
Multipour Number					

	2100	core metting para	Data		
Time Start	,	•			
Time Probe Down	•	•	-	Į.	
Time Finish					
Pration of Pour				•	
Probe Temperature					
Probe Unit Number	ı	,			

TEST CROUP A

Test Number	2	3	2	2	
Date	8/28/73	8/28/73 8/28/73 8/28/73 8/28/73	8/78/13	8/28/73	
Skid Number	6	10	11	12	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Suroud Time	7.5	2,	2,		
Cooling Bay Temp. Averages					
Y	87	88	89	89	
В					
υ	16	. 16	8	06	
Q	89	38	68	88	
Вау	95	95	\$6	8	

Number of Acils Poured	09	09	99	3	
Number of Criticals	0	ပ	1	0	
Number of Minors	0	0	°	°	
Number of Cavities	c	0	-	۰	
Number of Good Shells	ე9	09	59	9	
Maximum Area of Cavity	0	0	26.5	0	
Average Area of Cavity	0	0	26.5	0	
Median Area of Cavity	-				
Total Area of Cevity	0	0	26.5	•	

Test Mumber	ĵ				
Date	8/29/33				•
Skid Number	5	01	11	21	

	242) pane m	(mai aciti) pana madramii		•
Reservoir Temperature	188	194	761	751	
Cup Temperature	188	188	188	190	
Material Temperature	182	183	.185	16>	
Shell Temperature	"	70	7.5	75	
Time Poured	9:44	9:54	10:02	10:01	
Duration of Pour	38	37	37	37	
Multipour Number	2	2	2.	ž	

			/		
Reservoir Temperature	•	•	•	•	
Cup Temperature	•	•	٠	•	
Material Temperaturo	•	•	•	•	
Time Poured	•	•	•	•	
Duration of Pour	•	•	•	•	
Multipour Number	,	•	•	•	

Core Melting Data

Time Start	•	•	•	•	
Time Probe Down	•	•		•	
Time Finish	,	•	•	•	
Duration of Pour	,	•	•	•	
Probe Temperature	•	•		•	
Probe Unit Number	•	•	•	•	

TEST GROUP A

• 1

Test Mumber	,	J	~	~	
Date	8/29/73	8/29/73 8/29/73 8/29/73	8/:9/73	8/29/73	
Skid Nurber	2	10	-	-	

Cooling Bay , ata

Cooling Bay - Position	3-6	02:-	- T	3-13	
Length of Shroud Time	7.5	2	,	×	
Cooling Bay Temp. Averages					
Ą		8			
æ		68			
ပ		06			
Q		88			
Вау	%	8	96	97	

Musber of Shells Poured	09	90	99	9	
Number of Criticals	c	ť	1	0	
Number of Minors	ڻ	7	0	0	
Number of Cavities	0	3	1	0	
Number of Good Shells	09	57	54	139	
Maximum Area of Carity	0	34.5	37.5	0	
Average Area of Cavity	0	ħĈ	37.5	o	
Median Area of Cavity	•		•		
Total Area of Cavity	0	م	5.7.5	Э	

TEST GROUP A

Test Mumber	7				
Date	(k/12/8	î			
Skid Number	۶	ç	,	æ	=

Multipour Data (First Pour)

Reservoir Temperature	177	921	9/1	176	841
Cup Temperature	178	178	178	871	17.8
Material Temperature	176	921	176	9/1	175
Shell Temperature	8.2	28	:)8	98	80-87
Time Poured	1 22	7-25	7.32	7.35	9:57
Duration of Pour	47	05	87	87	5,
Multipour Number	2	3	ž.	2	~

Multipour Data (Second Pour)

D					
Meservoir resperature		•	•	•	•
Cup Temperature	•		•	•	
Material Temperature		•		•	
Time Poured	1		•		
Duration of Pour	•		•	•	•
Multipour Wanber			•		

Core Melting Data

	100	core mercang para	Para		
Time start	•		•	•	•
Time Probe Down	•	•		•	•
Time Finish			,	1	,
Duration of Pour	•	•		ŧ	•
Probe Temperature	•	•		•	•
Probe Unit Number	•		,	•	٠

TEST GROUP A

Test Number	7	,	7	7	7
Date	8/27/73	8 27,73 8,27,73 8,27,73 8,27,73	8,27,73	8/27/73	8/27/3
Skid Number	``	4	,	'n	

Cooling Bay ata

Cooling Bay - Position	3-5	3-6		3-8	
Length of Shroud Tire	25	7.5	7,5	2,5	2.5
Cooling Bay Temp. Averages					
Y	45	16	65	92	٠
В	16	56	16	16	•
υ	6	26	.6	26	•
, Q	06	<u>\$</u>	96	96	•
Вву	65	16	16	46	•

Number of Shells Foured	9	99	90	60	٥٥
Number of Criticals	٥	_	,	u	0
Number of Minors	٩	-	ŋ	1	o
Number of Cavities	11	٠.	~	1	0
Number of Good Shells	ن	x,	ď,	دد	09
Haximum Area of Cavity	22.5	25.	·.	.•	c
Average Area of Cavity	16. 1	0.15	9.51	!	c
Median Area of Cavity	18.5		0.65		o
Total Area of Cavity	5'041	1.54	0.63	17.5	0

TEST GROUP A

}	8/28/73 8/28/73	8
٢	8/28/7	,
3	8/28/73 8/28/73	٠
3	8/28/73	۶
Test Araber	Date	Skid Number

Multipour Data (First Pour)

Recervoir Temperature	182	182	180	182	
Cup Temperature	182	184	182	184	
Material Temperature	177	177	179	179	
Shell Temperature	80	82	80	81	
Time Poured	7:37	7:41	7:47	7:50	
Duration of Pour	42.5	44	45	45	
Multipour Number	2	2	(4	2	

Multipour Data (Second Pour

			,		
Reservoir Temperature	•	•	•		
Cup Tenperature	•	•	•		
Material Temperature	•	•	•		
Take Poured .	•		•		
Duration of Pour		•		•	
Multipour Munber	•	•	•	•	

ore Melting Data

		•			
Time Start	•	•		•	
Time Proue Down	•	•	•	•	
Time Pinish	•		•	•	
Duration of Pour	•	•		•	
Probe Temperature	•	•	•	•	
Probe Unit Number	•	•		•	

TEST GROUP A

Test Number	\$	۶	\$	\$	
Date	8/28/73	8/28/73 8/28/73 8/28/73 8/28/73	8/28/73	8/28/73	
Skid Number	\$	9	^	60	

Cooling Bay Data

Cooling Bay - Fosition	3-5	3-6	3-7	3-8	
Length of Shroud Time	75	7.5	52	7,	
Cooling Bay Temp. Averages					
٧	68	89	68	68	
B					
	16	92	26	16	
Q	89	69	69	88	
Bay	96	%	5 3	26	

Number of Shells Poured	09	09	90	09	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	2	ı	1	
Mumber of Good Shells	09	09	9	9	
Maximum Area of Cavity	0	2.0	3.0	2.0	
Average Area of Cavity	0	1.5	ο•ε	2.0	
Median Area of Cavity	•	-	•		
Total Area of Cavity	0	3.0	3.0	2.0	

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TEST GROUP A

Test Number

Skid Number Date

8/29/73

9 9 9 9	8/29/73 8/29/73 8/29/73 8/29/73	5 4 2
Test Number	Date	Skid Number

Cooling Bay Date

		A			
Cooling Bay - Position	3-5	3.6	2.	2	
Length of Shroud Time	75	2,	6	8	
Cooling Bay Temp. Averages					
У	92	26	8	6	
В	16	, 7	100	5	
၁	26	. 26	92	6	
Q	.86	8	8	8	
Bay	97	7,6	8	8	

9:07

2:59

7:45

2

35

38 . 2

8

Duration of Pour Multipour Number

Time Poured

80

8

184 186

185 186

Multipour Data (First Pour)

194

194 186 183 80

192

Reservoir Temperature

Material Temperature Shell Temperature

Cup Temperature

982 181 80

_			and vesuits			
Т	Number of Shells Poured	9	09	9	99	
<u> </u>	Number of Criticals	٥	٥	-	c	_
	Number of Minors	-	٥	-		
-	Number of Cavities		°	~		
	Number of Good Shells	89	9	88	9	
	Maximum Area of Cavity	24.5	٥	32.0	٥	
_	Average Area of Cavity	24.5	·	32:5	5	
T	Median Area of Cavity			•	3	
_	Total Area of Cavity	24. 5	0	57.5	3	

Pour)
(Second
Data
tipour
3

	74.	The rate	merchant para (second bout)	ì	
Reservoir Temperature	•				
Cup Temperature	•	•	•		
Material Temperature	•	•		•	
Time Poured	•				
Duration of Pour	•				
Multipour Number	•				

Core Melting Data

		2000			
Time Start	•			·	
Time Probe Down	•			•	
Time Finish	•		•		
Duration of Pour	•				
Probe Temperature					
Probe Unit Number	٠				

TEST CROUP A

Test Maber Date Skid Masber

Multipour Data (First Pour)

177	179	179
178	170	
ľ		179
176	176	176
%	93	8
6:52	6:58	7:01
•	-	17
2	2	2
6:52		6:58

Multipour Data (Second Pour)

				The second second second	
Reservoir Temperature	•	٠	•	•	
Cup Temperature	•	•	•	•	
Material Temperature	•	•	•		
Time Poured	•	•	•	•	
Duration of Pour	•	•	•	•	
Multipour Mumber	•	•	•	•	

Core Melting Date

Time Start		٠	,	•	
Time Probe Doen		•			
Time Pinish				•	
Euration of Pour			•		
Probe tamperature	•	•	•		
Probe Unit Mumber	•	•	•		

TEST GROUP A

£.

Test Number	7	,	٤	^	
Date	8/27/73 8/27/73 8/27/73	8/27/73	8/27/73	8/27/73	
Skid Mumber		2	3	7	

Cooling Bay .ate

Cooling Day - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	7.5	. 51	7.5	25	
Cooling Bay Temp. Averages					
Y	91	16	16	16	
æ	8	06	8	ş	
ပ	91	91	16	16	
Q	06	06	06	96	
Bay	6	66	*	*	
				20000	

X-Ray Results

Number of Spelle Poured	4	9	Ş	إ	
		3	8	3	
Number of Criticals	1	0	٠	m	
Number of Minors	13	12	°.	0,7	
Number of Cavities	15	13	17	97	
Number of Good Shells	46	87	\$7	17	
Maximum Area of Cavity	32.5	27.5	25.5	25.5	
Average Area of Cavity	17.6	18.7	18.4	16.4	
Median Area of Cavity	0.61	17.5	18.0	16.5	
Total Area of Cavity	264.0	244.0	313.0	313.0 674.0	

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, , ,	8/28/73 8/28/73 8/28/73	moter 8 8 8 8			8/28/73	8/28/73	8/28/73	8/28/73	Test Munber Date
-------	-------------------------	---------------	--	--	---------	---------	---------	---------	---------------------

	drame	THE THE STORY	nutripour nata (First Four)	<u>.</u>	
Reservoir Temperature	186	186	187	١	
Cup Pemperature	184	182	182	187	
Meterial Temperature	182	180	182	180	
Shell Temperature	92	92	16	8	
Time Poured	97:9	13.9	L		
Duration of Pour	36	35		, s	
Multipour Number	2	2	,	·	

	Multipo	ur Data (Multipour Data (Second Pour)	(m)	
Reservoir Temperature			 -		
Cup Temperature					
Material Temporature	-			,	
Time Poured	'		 	•	
Duration of Pour			•	•	
Multipour Number			-	•	

Core Melting Data

Time Start	•	,		
Time Probe Down			-	
Time Finish	•			
Duration of Pour	•	•		•
Probe Temperature		•	•	
Probe Unit Number	•	į	:	

Test Number	8	30	80	8	
Date	8/28/73 8/28/73 8/28/73 8/28/73	8/28/73	8/:8/73	8/28/73	
Skid Nurber	-	2	٦	7	

Cooling Bay Data

Cooling Bay - Position		?-:	3-3	7.5	
Length of Shroud Time	25	2	2	ž	
Cooling Bay l'mp. Averages					
٧	8	06) 	S	
В					
O	92	8	89	6	
D	ક	8	96	8	
Bay	97	97	46	6	
			•	•	

Number of Shells Poured	09	09	 -	65	
"umber of Criticals	12	2	 -	-	
Number of Minors	30	38	=	2	
Number of Cavities	47	77	91	9	
Number of Good Shells	18	20	87	13	
Maximum Area of Cavity	31.0	35.5	23.5	34.0	
Average Area of Cavity	19.1	19.8	14.9	14.0	
Median Area of Cavity	10.0	19.0	16.5	14.5	
Total Area of Cavity	862.5	871.5	224.5	182.0	

TEST CROUP A

Test Number	6				
Date	8/29/73				
Skid Number	1	2	3	7	

Multipour Data (First Pour)

Reservoir Temperature	190	190	190	190	
Cup Temperature	186	981	186	186	
Material Temperature	183	183	184	183	
Shell Temperature	92	76	92	66	
Tine Poured	6:52	65:9	7.03	7:08	
Duration of Pour	37	SE	33	SE	
Multipour Number	2	2	ē .	?	

Cup Temperature Cup Temperature Mater al Temperatura Time Poured Duration of Pour		odramu	ur vaca l	nuttipour paca (second rout)	, ,	
Cup Temperature	Reservoir Temperature	-	•	•	•	
Mater al Temperatura Thme Poured Duration of Pour Multitour Manher	Cup Temperature	•	٠		•	
Time Poured Duration of Pour Multitour Munber	Mater al Temperatura	•	•	•	•	
Duration of Pour	Time Poured	•		•	٠	
Mil though Maples	Duration of Pour	•	•	•	•	
	Multipour Number	•	•	•	•	

Time Start	•	•	•	•	
Tine :robe Down	•	,	•	•	
Tine Finish	•	,	•	•	
Duration of Pour	•	•	•	,	
Probe Temperature		•	•	•	
Probe Unit Number	•		•	;	

TEST CROUP A

Test Number	6	6	٠	0	
Date	8/29/73	8/29/73 8/29/73 8/29/73	8/29/73	8/29/73	
Skid Number	-	2	3	,	

Cooling Bay Data

92 92 92 92 92 92 92 92 92 92 92 92 92 9	3-2 3-3 3-4
91 91	
92 92	
16 16	
92	
į	
-	16 16 16
Bay 97 97 97	

X-Ray Results

Number of Shells Poured	\$8*	9	09	99	
Number of Criticals	2	٥)	ŋ	
Number of Minors	28	42	31	97	
Number of Cavities	35	76	37	53	
Number of Good Shells	28	18	92	14	
Maximum Area of Cavity	33.0	22.0	37.5	41.0	
Average Area of Cavity	19.4	15.2	23.2	19.2	
Median Area of Cavity	20.5	16.0	23.5	19.0	
Total Area of Cavity	734.5	213.5	0.038	961.0	

as the explosive level was too low to produce *D-'eted shells #5 and #59 a good shell.

Test Number	10	10	01	01	
Date	8/30/73	8/30/73	8/30/73 8/30/73 8/30/73 8/30/73	8/30/73	
Skid Number	1	2	3	7	

	•		(1)		
Reservoir Temperature	178	178	178	178	
Cup Temperature	180	180	179	179	
Material Temperature	176	176	176	176	
Shell Temperature	80	80	8/	82	
Time Poured	7:07	7:18	7:28	7:32	
Duration of Pour	47	43	41	41	
Multipour Number	2	2	2	2	

				•	
Reservoir Temperature	•	•	-	•	
Cup Temperature	•	-	-	•	
Material Temperature	•	-	•		
Time Poured	•	-	•		
Duration of Pour	•	•	-	•	
Multipour Number	-	٠	•	,	

		9			
Time Start	•	•		•	
Time Probe Down		,	1	•	
Time Finish	•	,	•	•	
Duration of Pour	•	•		-	
Probe Temperature	•	•	•	•	
Probe Unit Number	•		•	•	

TEST "ROUP A

. Test Number	10	10	10	21	
Date	8/30/73 8/30/73 8/30/73	8, 30/73	8/30/73	8/30/73	
Skid Number	1	2	3	,,	

Cooling Bay - Position	3-1	3:	3-3	3.6	
Length of Shroud Time	75	"	2	2	
Cooling Bay Temp. Averages					
Y	89	89	89	88	
В	89	86	89	ž	
O	89	3	85	69	
Q	87	87	87	98	
Bay	76	76	ż	3	

Number of Shells Poured	2	20	ā	1	
Number of Criticals	,]	3	3 =	
Number of Minors	,	3	-	,	
Number of Cavities	د	3	5 3	-	
Number of Good Shells	ņ	iò	ā	à	
Maximum Area of Cavity	٥	-	3	=	
Average Area of Cavity	,	د	٥	, 3	
Median Area of Cavity	د	٥	9	3	
Total Area of Cavity	J	5	٥	٥	

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Test Number	01	10	. 10	01
Date	8/30/73	8/30/73	8/30/73 8/30/73 8/30/73 8/30/73	8/30/73
Skid Number	\$	9	7	8

	מלים דייי	/ mai aciril hama madramii			
Reservoir Temperature	178	180	186	190	
Cup Temperature	179	180	180	180	
Material Temperature	173	174	174	175	
Shell Temperature	85	78	77	RO	
Time Poured	/:39	7:45	7:49	7.56	
Duration of Pour	44	43	47	07	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	•	•	•	•	
C Temperature	•	•	•	•	
terial Temperature	•	•	•	•	
Time Poured .	•	•	•	•	
Duration of Pour	•	•	•	•	
Multipour Number	•	•	-	•	

•)			
Time Start	•	•	•	•	
fine Probe Down	•	•	•	•	
Time Finish		•	٠	•	
Duration of Pour		٠	٠	•	
Probe Temperature	•		٠	•	•
Probe Unit Number		•		•	

TEST GROUP A

Test Number	10	10	10	10	
Date	8/30/73	8/30/73 8/30/73 8/30/73 8/30/73	8/30/73	8/36/73	
Skid Number	\$	9	,	8	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	25	7.5	<i>\$1</i>	5.2	
Cooling Bay Temp. Averages					
А	89	89	89	89	
В	89	89	89	89	
່	89	58	89	06	
D	86	98	87	48	
Вау	76	76	76	ま	

Number of Shells Poured	9	9	09	60	
Number of Criticals	С	0	0	0	
Number of Minors	1	0	0	С	
Number of Cavities	1	ن	၁	0	
Number of Good Shells	89)9	09	9	
Meximum Area of Cavity	36.5	o	0	0	
Average Area of Cavity	36.5	0	0	0	
Median Area of Cavity	•	٠			
Total Area of Cavity	36.5	3	0	0	

Test Mumber	11	n	=	٦	
Date	8/30/73 8/30/73		8/30/73	1/30/73	
Skid Number	6	01	11	12	

	Multipo	ur Data (Multipour Data (First Pour)	<u> </u>	
Reservoir Temperature	184	184	184	188	
Sup Temperature	182	182	182	130	
Material Temperature	180	180	180	180	
Shell Temperature	82	\$	78	83	
Time Poured	8:44	8:47	8:52	9:20	
Duration of Pour	36	70	•	ä	
Multipour Number	2	2	2	2	

Reservoir Temperature	•	•	•	•	
Cup Temperature	•				
Material Temperature	٠			,	
Time Foured	•		٠	,	
Duration of Pour					
Multipour Musber	•				

	Core	Core Melting Data	Data	
Time Start	•		Ŀ	
Time Probs Down		•		
Time Finish	•			
Duration of Pour			 -	
Probe Temperature				
Probe Unit Mumber		•		

TEST CROUP A

Test Number	11	11	=		
Date	8/30/73	8/30/73 8/30/73	8/30,73 8/30/73	8/36/73	
Skid Number	6	10	11	21	

Cooling Bay Data

Cooling Bay - Position	3-9	5-10	3-13	î	L
Length of Shroud Time	7.5	7.5	7.5	2,2	
Cooling Bey Temp. Averages					
. A	87	28	87	87	
В	28	87	87	85	
9	87	87 .	87	87	
D	.85	85	. 85	88	
Bay	92	92	92	26	

Number of Shells Poured	ş	8	9	3	
Number of Criticals	۰	•	•	-	
Number of Minors	14	7.	•	0	
Number of Cavities	19	17	•	۰	
Number of Good Shells	97	97	99	89	
Maximum Area of Cavity	37.5	20.5	0	29.62	
Average Area of Cavity	19.2	20.6 0	14.2		
Median Area of Cavity	19.5	23.0		13.0	
Total Area of Cavity	364.5	351.5	0	88.0	

		-			
Test Number	11	11	11	11	
Date	8/30/73	8/30/73	8/30/73 8/30/73 8/30/73	1.2/00/8	•
Skid Number	Ξ	71	15	91	

Asservoir Temperature	186	186	185	1.15	
Cup Temperature	180	180	181	181	
Material Temperature	180	180	180	182	
Shell Temperature	84	85	84	63	
Time Poured	9:23	9:27	9:31	9:36	
Duration of Pour	37	3	35		
Multipour Number	2	,	. 2	2	

rature		ature			
Reservoir Temperature	Cup Temperature	Material Temperature	Time Powed	Duration of Pour	Multipour Number

	9103	core moiting mara	LOG T. G		
Time start				•	
Tine Probe Down					
Time Finish		•		•	
Duration of Pous					
Probe Temperature			•	•	
Probe Unit Number					

TEST GROUP A

Test Number	11	=	Ξ	11	
Date	8/30/73	8/30/73 8/30/73 8/30/73	8/30/73	8/30/73	
Skid Number	13	14	115	16	
	Cooli	Cooling Bay Late	2		
Cooling Bay - Position	ù-1,	3-14	5-9	2-10	
Length of Shroud Time	7.5	75	75	7.5	
Cooling Bay Temp. Averages					
Y				•	
æ			•	•	
ບ			•	•	
D			•	•	
Вау	93	z	06	06	

Number of Shells Poured	99	09	9	99	
Number of Criticals	ô	J	0	2	
Number of Minors	2	'	0	Ą	
Number of Cavities	2	6	0	8	
Number of Good Shells	.58	53	09	52	
Maximum Area of Cavity	22.5	32.5	0	34.5	
Average Area of Cavity	17.5	21.8	٥	23.2	
Median Area of Cavity	•	26.5		28.5	
Total Arca of Cavity	35.0	196.0	0	202.0	

TEST GROUP B

PURPOSE

The purpose of this group was to run a variable study on hot topping. The general objective of hot topping is to create a hotter reservoir of material in the funnel section so as to prolong the time before the former section freezes over.

PROCEDURE

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There were two variables; the explosive temperature for the first pour at 176° and 184°F; and the height of the first pour at the top of the former and at 3/4 up the former (3 1/2 inches from the break off). All hot top offs were targeted for 200°F, with an approximate 1 minute delay between pours. All shells were targeted for 80°F and cooling bays were at a high temperature.

Comp B with Petrolite ES 670, Lot 053-5050, was used with scrap incorporated at 40%.

For each test, four skids, or 240 shells, were poured. The insulated, wooden shroud was used for all skids.

The X-rays were gridded in a similar manner to those for Group A.

DISCUSSION

GROUP B TWO INCREMENT POURING

Test #	1st Increment	2nd Increment	Height of First Pour
1	176	200	Top of former
2	176	200	3/4 way up former
3	184	200	Top of former
4	184	200	3/4 way up former

NOTES:

- 1. Shell and funnel temperature 80°F nominal record actual temperature.
- 2. The maximum time between pours was 1 minute.
- 3. Composition B containing Petrolite ES670 wax with 40% riser scrap.
- 4. Four skids per test.

GROUP B TWO INCREMENT POURING DEFECT SUMMARY

Explosive Temperature

	176°/200°	184°/200°	
Height of First Pour	1		3
Top of Former	4C	0	
	2		4
3/4 of Former	1M*	0	

*See discussion for explanation of minor defect.

GROUP B TWO INCREMENT POURING GRIDDING SUMMARY

Explosive Temperature

	176°/200°	184°/200°	
Height of First Pour	1		3
Top of Former	129.5	0	
	2		4
3/4 Up Former	27.5*	0	

*See discussion for explanation of minor defect.

TEST CROUP B

Test Number		1	1	-	
Date	1/5/6	8/4/73 9/4/73 9/4/73		9/4/73	
Skid Number	1	2	3	7	

			, man a same s a same	•	•
Reservoir Temperature	174	721	221	172	
Cup Temperature	176	7/1	7/1	721	
Katerial Temperature	178	117	9/1	176	
Shell Temperature	78	78	82	80	
Time Poured	7:57	8:01	8:04	90:5	
Duration of Pour	33	33	33		
Multipour Number	2	2		2	

ture - 198 200 198 198 ture 194 195 198 7:04 8:02		Multipo	ur Data	Multipour Data (Second Four)	ur.)	
194 195 198	Reserveir Temperature	•	861	200	200	
194 195 198 7:04 8:02	Cup Temperature	•	198	198	861	
7:04 8:02	Material Temperature	761	195	198	861	
Duration of Pour	Time Poured		7:04	8.02	9:10	
	Duration of Pour	•				
Multipour Number	Multipour Number		-	-	-	

Tine Probe Down Tine Finish Duration of Pour Probe Temperature			מוני ייביבייו פייבי	3		
Tine Finish Duration of Pour Probe Unit Humber	Time start	•	-			
Duration of Pour	Tine Probe Down	•		•		
Probe Unit Number	Time Finish	•			٠	
Probe Temperature	Duration of Pour		•	1	•	
Probe Unit Number	Probe Temperature	•	•	•		
	Probe Unit Number	•		4	•	

TEST GROUP B

Test Mumber	1	1		_	
Date	912.73	914.73 014.73 04.73 914/73	0 4 73	9/4/73	
Skid Number	1	١.4	٦	7	

Cooling Bay Data

Length of Shroud Tine 75 75 75 Cooling Bay Temp. Averages 85 85 85 85 B 86 86 86 86 86 C C 86 86 86 86 86 B B 85 85 85 85 88	Cooling Bay - Festion	1-1	. <u>.</u>	Ĩ.	7-1	
85 85 85 86 86 86 87 85 85 88 88 88	Length of Shroud Time	7,5	7.5	7.5	×	
85 85 85 86 86 86 87 85 85 88 88 88	Cooling Bay Temp. Averages					
38 38 38 48 58 58 48 58 88 48 48 88 48 48 48 48 <	~	85	85	85	8	
86 86 86 85 85 85 88 88 88	3	86	86	98	98	
85 85 85	Ü	86	98	86	98	
88 88	Q	85	85	85	85	
	Baj	88	88	88	88	

X-Ray Results

Number of Shells Poured	*65	9	09	9	
Number of Criticals	2		0	7	
Number of Minors	0	0	0	٥	
Number of Cavities		3	0	-	
Number of Good Shells	52	49	09	0,	
Maximur Area of Cavity	26.4	ř.	5		
Average Area of Cavity	1:.4	15.2	0		
Median Area of Cavity	۰,4	6.4	ئ		
Total Area of Cavity	38.6	45.5	3	26.0	

*Shell 46 omitted.

TEST CROUP B

Test Number	2	2	. 2	2	
Date	61/4/6	8/4/73 9/4/73	61/5/6	67/4/6	
Skid Number	13	71	15	91	

Multipour Data (First Pour)

	7	3000	(mar active) same moderami	•	
Reservoir Temperature	174	175	173	174	
Cup Temperature	180	181	182	180	
Material Temperature	178	184	178	178	
Shell Temperature	80	80	80	80	
Time Poured	11:01	11:04	11:09	11:11	
Duration of Pour	40	36	34	34	
Multipour Number	2	2	2	2	
				The second secon	

Multipour Data (Second Pour)

Reservoir Temperature	199	199	198	198	
Cup Temperature	198	198	198	198	
Material Temperature	198	194	761	194	
Time Poured	11.05	11:06	11:11	11:13	
Puration of Pour	•	•	-	•	
Multipour Number		1	1	1	

Coro Melting Data

	000	and Sittation of the	-		
Time Start	,	•	•	•	
Time Probe Down	•				
Time Finish	•	•	•	•	
Duration of Pour	•	•	•		
Probe Temperature	•	•	•	•	
Probe Unit Number		•	•	•	

TEST CHOUP B

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Test Number	2	2	2	2
Date	9/4/73	9/4/73 3/4/73 9/4/73	9/4/73	8/4/13
Skid Number	13	14	15	91

Cooling Bay Data

		•			
Cooling Bay - Position	3-13	7-8	2-9	2-10	
Length of Shroud Time	75	6/	25	25	
Cooling Bay Temp. Averages					
γ	86	85	85	85	
æ	87	•		•	
O	98	•		•	
a	78.			-	
Bay	89	85	85	85	

X-Ray Results

Number of Criticals 0 0 Number of Minors 1 0 Number of Cavities 1 0 Mumber of Good Shells 17 60 Maximum Area of Cavity - 0 Average Area of Cavity - 0 Median Area of Cavity - 0	Number of Shells Poured	18*	9	09	09	
1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Number of Criticals	0	0	0	0	
11s 17 60 14ty - 0 14ty - 0 14ty - 0 15ty - 0	Number of Minors	7	0	0	0	
17 60	Number of Cavities	1	0	0	0	
Maximum Area of Cavity - 0 Average Area of Cavity - 0 Hedian Area of Cavity - 0	Number of Good Shells	17	90	09	09	
Average Area of Cavity - 0 Median Area of Cavity - 0	Maximum Area of Cavity	•	0	Ç	0	
Median Area of Cavity - 0	Average Area of Cavity	•	0	0.	0	
	Median Area of Cavity	•	0	0	0	
Total Area of Cavity 27.5 0	Total Area of Cavity	27.5	0	0	0	

*Most of the shells were poured too low.

TEST CROUP B

Test Mumber	~		. 3	3	
Date	9/4/73	9/4/73	6/4/13	9/4/73	
Skid Number	\$	9	4	80	

		ם מחום	(mor again) Bana moderami		
Reservoir Temperature	182	182	182	182	
Cup Temperature	184	781	184	183	
Material Temperature	185	781	781	183	
Shell Temperature	RO	90	08	80	
Time Poured	9:03	9:12	9:15	9:19	
Duration of Pour	35	30	7 C	32	
Multipour Number	2	2	2	2	

hittpour Data (Second Pour)

	MULTIPO	ur Data (munitipour nata (second Four)	Ę	
Reservoir Temperature	201	102	200	200	
Cup Temperature	200	200	200	200	
Material Temperature	198	198	192	193	
Time Poured	60:6	9:13	9:16	9:20	
Duration of Pour			•		
Multipour Musber	1	-	-	-	

Core Melting Data

			•	•	
Time Start	Time Probe Down	Time Finish	Duration of Pour	Probe Temperature	Probe Unit Humber

TEST CROUP B

Test Number	3	3	٤	ъ	
Date	9/4/73	61/7/6 81/7/3	9/4/13	6/77/6	
Skid Number	\$	9	٤	8	

Cooling Bay Lata

Cooling Bay - Position	3-5	3-6	3-7	8.	
Length of Shroud Time	75	2,2	2,	2	
Cooling Ray Temp. Averages					
Y	85	85	85	86	
В	86	86	86	98	
S	98	96	86	98	
D	85	84	78	78	
Bay	88	88	88	8%	

Number of Shells Poured	\$65	09	09	09	
Number of Criticals	0	0	0	0	
Number of Minors	د	0	0	o	
Number of Cavities	0	0	0	0	
Number of Good Shells	59	96	99	96	
Maximum Area of Cavity	۵	0	3	o.	
Average Area of Cavity	0	0	Э	0	
Median Area of Cavity	n	o	٥	٥	
Total Area of Cavity	0	. 0	0	٥	

*Shell 3 omitted as it was poured too low to produce a good shell.

Test Number 4 <th< th=""><th></th><th></th><th></th><th></th><th></th><th></th></th<>						
9/4/73 9/4/73 9/4/73	Test Number	7	7	7	7	
Skid Number 9 10 11 12	Date	9/4/73	6/4/13	9/4/73	9/4/73	
	Skid Number	9	10	11	12	

			-		
Reservoir Temperature	186	186	186	186	
Cup Temperature	185	184	781	781	
Material Temperature	184	184	184	184	
Shell Temperature	80	82		82	
Time Poured	10:02	10:10	10:12	10:14	
Duration of Pour	•	29	30	30	
Multipour Number	2	2	2	2	

Reservoir Temperature	1 198	198	82	388	
Cup Temperature	198	197	197	187	
Material Temperature	•	200	200	200	
Time Foured .	10:09	. 10:12	10:13	10:15	
Dration of Pour	•	•			
Multipour Number	1	-	-	-	

				•		
					•	
325	•				•	•
rore meterng mara	•		•		•	•
core	•	•	•	•	•	•
	Time Start	Time Probe Down	Time Fig. 1.	Duration of Pour	Probe Temperature	rrobe Unit Number

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Test Number	7	4	7	7	
Date	9/4/73	9/4/73	9/4/73 9/4/73 9/4/73	9/4/73	
Skid Number	6	ë	11	12	

	T ·						
212	22		1		*	2	\$
3-11	2,5		78	ž		26	89
3-10	7.5		\$8	8.5) 8	85	89
3-9	7.5		85	58	86	85	89
Cooling Bay - Festtion	Length of Shroud Time	Cooling Bay Temp. Averages	Y	B	υ	D	Bay

Number of Shells Poured	90	9	9	00	
Number of Criticals	0	0	0	۰	
Number of Minors	0	0	٥	: L	
Number of Cavities	0	0	ა	0	
Number of Good Shells	60	09	99	99	
Maximum Area of Cavity	0	0	0	٥	
Average Area of Cavity	0	0	°	0	
Median Area of Cavity	0	0		۰	
Total Area of Cavit	ű	٥	ļ °	٦	

GROUP C PROBING

Test #	Explosive Temperature	Time Duration of Probe, Min.
1	176	5
2	180	5
3	176	2.5
4	180	2.5
5	176/200	5
6	176/200	2.5
7	176/200	In-Out

NOTES:

- 1. The maximum probe pressure was 10 psig.
- 2. Depth of probe was 1 to 2 inches above the break-off point.
- 3. Shell temperature was $80^{\circ}F \pm 2^{\circ}F$ record actual temperature.
- 4. Time to start probing was 5+1 minutes after first pouring.
- 5. Four skids per test.
- 6. Composition B containing Petrolite ES670 wax with 40% riser scrap was used.

GROUP C PROBING GRIDDING SUMMARY

Probe Time

	5 minutes	2.5 minutes	10-15 seconds
176 ⁰	0	0	
180 ⁰	330	0	•
176°/200°	0	60 60	62 62

GROUP C PROBING DEFECT SOMMARY

Probe Time

	5 minutes	2.5 minutes	10-15 sec
176 [°]	0	0	-
180°	1C 15M	0	-
176 ⁰ /200 ⁰	0	1C 1M	7 1C

ţ	ر
2	5
	3

Test Mumber	-	1	1	-	
Dete	8/5/73	51.13 9/5,73	8/8/73	8/5/73	•
Sicia Mumber		2	3	7	

	wat t po	ur terts 1	mutipour meta (ritat rom.)	.,	•
Reservoir Temperature	174	175	176	178	
Cup Temperature	182	182	180	178	
Material Temperature	176	441	178	221	
Shell Temperature	90	6/	82	82	
Time Poured	7:07	7:11	7:22	7:27	
Duration of Pour	\$7	34	(7	57	
Multipour Mumber	2	2	. 2	2	

Multipour Data (Second Pour)

	•		-		
Reservoir Temperature	•		•	•	
Cup Temperature	-	•	•		
Material Temperature			,	•	
Time Poured			•	•	
Duration of Pour		•	•	•	
Multipour Number		•	٠	•	

Core Meltine Data

	200	ממנה מוציו היות השנים	2000		
'lime Start	7:13	7:16:30 7:27	7:27	7:32	
Time Probe Down	•	7:16:36		7:32:0	
Time Finish	7:18	7:21:30 7:32	\$:32	7:37:04	
Duration of Pour	•	•	•	•	
Probe Tamperature	220		220	230	
Probe Unit Number	•	•	•	•	

TEST COURS

Test Number	1	-1	1	1	
Date	5/5/23	6/5/73 8/5/73	8/2/3	9/5/73	
Skid Number	1	2	£	7	

Cooling Bay Data

Cooling Bay - Position	4-1	3-1	4-2	3-2	
Length of Shroud Time	75	7.5	75	51	
Gooling Bay Temp. Averages					
Y	86	85	88	\$8	
В		88	•	79	
		85		78	
Q		87	•	86	
Bay	89	89	89	88	

X-Ray Results

Number of Shells Poured	9	*65	9	09	
Number of Criticals	ر 	0	0	0	
Number of Minors	0	0	0	0	
Number of Gavities	0	0	0	0	
Number of Good Shells	99	65	09	09	
Maximum Area of Cavity	0	O	0	0	
Average Area of Cavity	0	0	0	0	
Median Arce of Cavity	٥	0	0	0	
Total Area of Cavity	0	0	0	c	

+Shell #20 omitted as it was poured too low to produce a good shell.

Added tool the same of

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Test Number	\$	2	. 2	2	
Date	9/5/73	57/5/6 52/5/6	6/2/13	9/5/73	
Skid Number	13	71	\$1	11	

	Multipo	ur Data (Multipour Data (First Pour)	<u>ت</u>	
Reservoir Temperature	182	184	183	183	
Cup Temperature	182	081	181	182	
Material Temperature	180	183	184	186	
Shell Temperature	79	08	80	80	
Time Poured	9:13	9:31	9:36	9:39	
Duration of Pour	37	35	40	37	
Multipour Number	2	2	2	2	

Reservoir Temperature	•	•		•	
Cup Temperature	•	•	-	•	
Material Temperature		•	•	•	
Time Poured		•	•	•	
Duration of Pour		•	٠	•	
Multipour Musber	,		•	•	

•	,	DOMA GUYATAN A TAA			
Tine Start	9:18:30	9:18:30 9:36:04 9:41	9:41	77:6	
Time Probe Down		9:36:12	•	60:95:6	
Time Finish	9:23:30	9:23:30 9:41:04 9:46	9:46	67:6	
Duration of Pour	•		•	•	
Probe Temperature	220		220	230	
Probe Unit Number	•	•			

Test Number	2	2	2	2	
Date	9/5/73	9/5/73 9/5/73	6/5/13	9/5/73	
Skid Number	13	14	15	91	

Cooling Bay Data

Cooling Bay - Position	4-7	3-12	8-7	-7	
Length of Shroud Time	7.5	7.5	7.5	2,5	
Cooling Bay Temp. Averages					
	78	85	98	84	
В	•	84	•	78	
U	•	. 79	٠	78	
٥	•	85		85	
Bay	88	88	98	88	

Number of Shells Poured	9	9	ç	9	
Number of Criticals	0	0		۰	
Number of Minors	0	7	~	۰	
Number of Cavities	0	,	m	,	
Number of Good Shells	9	53	23	25	
Maximum Area of Cavity	0	31.5	25	27.5	
Average Area of Cavity	0	18	29:5	19.25	
Median Area of Cavity	0	19.5	27.5	19.5	
Total Area of Cavity	0	126	88.5	116.6	

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틹	
5	
S	

Test Mumber	3	3	٠	•	
Date	9/5/73	9/5/73 9/5/73	8/5/73	9/5/73	
Sicid Humber	\$	9	,		

Reservoir Temperature	178	179	179	178	
Cup Temperature 1:	177	177	178	178	
Material Temperature	176	177	176	111	
Shell Temperatume	. 08	82	08	80	
Time Poured 7:	7:34	7:39	7:43	7:50	
Duration of Pour 43	3	45	643	6,4	
Multipour Number 2	2	2	2	2	

ultinour Data (Second Pour)

	Multipo	ur Date (Multipour Data (Second Pour)	(H	
Reservoir Temperature .	•	•	•		
Cup Temperature	•	•	•		
Material Temperature	•	•		•	
Time Poured			•	•	
Duration of Pour	•	•	•	•	
Multipour Maber	•	•	•	,	

Core Melting Data

Time Start	7:39	87:2 90:77:2	87:2	7:55:05	
Time Probe Down		7:44:16		7:55:10	
Time Pinish	7:41:30	7:41:30 7.46:46		7:50:30 7-57:38	
Duratica of Pour	,				
Probe Temperature	220	234	220		
Probe Unit Number	•	•		•	

TEST GROUP C

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Test Number	3	3	3	3	
Date	9/5/73	8/5/73 8/5/73 8/5/73	8/8/13	61/5/6	
Skid Number	5	9	۷	8	

Cooling Bay '..ta

Cooling Bay - Position	4-3	3-3	7-7	3-4	
Length of Shroud Time	25	52	\$1	51	
Cooling Bay Temp. Averages					
Υ	88	\$8	88	58	
8	•	85	•	58	
Ð	• ;	78		78	
a		87	•	98	
Вау	89	88	80	88	

X-Ray Results

Number of Shells Poured	9	09	09	09	
Number of Criticals	0	0	0	0	
Number of Minors	0	υ	0	0	
Number of Cavitics	0	0	0	0	
Number of Good Shells	60	09	09	09	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	С	0	

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Tes. Munber	4	7	7	7	
	9/5/73	9/5/73 9/5/73	9/5/73	67/5/	
Sidd Number	9	01	11	12	

Reservoir Temperature 180	184	184	182
Cup Temperature	182	182	181
Material Temperature 178	179	160	081
Shell Temperature 80	77	98	80
Time Poured 8:47	9:52	8:59	9;03
Duration of Pour 44	41	17	39
Multipour Number 2	2	2	2

	The state of the s	-			
Reservoir Temperature		•	•	•	
Cup Temperature	•	•	•	•	
Material Temperature	•	•	•	•	
Time Poured	•	- '	•	•	
Duration of Pour		•	-	•	
Multipour Musber		-	٠	-	

	200	COLE NETCTING DACS	55		
Time Start	7:52	9:57:03	9:0%	9:08-03	
Time Probe Down		9:57:10	•	9:08:10	
Time Finish	7:54:30	9:59:45	9:06:30	7:54:30 9:59:45 9:06:30 9:10:33	
Duration of Pour			•		
Probe Temperature	220	230	220	•	
Probe Unit Number		•	•	•	

Test Number	7	7	7	7	
Date	9/5/73	61.173	57/5/9 67/5/9 67/5/9	8/8/73	
Skid Number	6	10	11	12	

Cooling Bay Lata

	- 1	, -			-
Position.	٠٠٠	3-10	9-7	١	
Length of Shroud Time	75	7.5	22	2	
Cooling Bay Temp. Averages					
	78	78	97	78	
	ı	78	٠	83	
•		84		83	
	ı	84	•	78	
	88	88	88	48	
					-

Number of Shells Poured	90	09	09	9	
Number of Criticals	ů	J	0	٥	
Number of Minors	c	Û	ິນ	ں	
Number of Cavities	0	0	0	U	
Number of Good Shells	0,4	6 t.	99	60	
Maximum Area of Cavity	'n	ı	0	0	
Average Area of Cavity	3	0	د	o	
Median Arca of Cavity	n	O	0	0	
Total Area of Cavity	o	0	0	0	

GNOUP C
TEST

Test Number	5	s	\$	'n	
Dete	81 19/6	9/6/13 9/6/73 9/6/73	67/9/6	6//9/6	
Skid Number	1	2	,	7	

6/13

6/6/13

9/6/73 9/6/73

Test Number

Date Skil Number Multipou Data (First Pour)

180

181

22

Material Temperature Shell Temperature

178

Reservoir Temperature

Cup Temperature

Coling Bay Data

] 	3-2	3-3	3-4	
一	75	7.5	75	7.5	
Cooling Bay Temp. Averages					
\dashv	986	87	86	86	
	8	8	8	%	
	84	78	79	84	
	98	86	98	86	
	8	06	8	8	

6:51

6:47

6:30

×

Duration of Pour

Time Poured

Multipour Number

≅|

X-Ray Results

Number of Shells Poured	9	9	េះ	\$8	
Number of Criticals	0	0	0	0	
Nurber of Minors	0	0.	0	0	
Number of Cavities	0	0	0	0	
Nurley of Good Shells	90	90	09	65	
Maximum Area of Cavity	0	0	0	0	
Average Area of Cavity	0	0	0	0	
Median Area of Cavity	0	0	0	0	
Total Area of Cavity	0	0	0	٥	

#Shell 55 omitted as it was poured too low to produce a good shell.

Multipour Data (Second Pour)

Reservoir Temperature	200	961	196	196	
Cup Temperature	196	198	198	198	
Material Temperature	202	200	199	200	
Time Foured	•	67:9	6:53	65.9	
Duration of Pour	•	•		,	
Multipour Number	1	1	-	ļ .	

Core Melting Data

	2700	החום שבדרדשו חקרש	Data		
Time Start	6:35	00-75-9	95:9 00-55.9	7.04:30	
Time Probe Down	-	6:54:03			
Time Finish	9.40	6:39	7:01	7.09.01	
Duration of Pour		,			
Probe Temperature	220	230	220	225	
Probe Unit Number	4	,	4	,	

ζ	4
2	
12	

	1631	CEST GROUP C			
Test Number	9	٩	ء ا	ď	
Date	6/9/6	9/6/73 9/6/73 9/6/73	9/6/73	9/6/73	
Skid Number	٧.	ı	,		
				,	

	•				
Reservoir Temperatura	178	178	1 70	9.	
Cup Temperature	177	178	178		
Material Temperature	:			3	
				178	
Shell Temperature	ŝ	Ş	ā		
			1		
Time Poured	2:08	7.12	3.18		
Duration of Pour	33	33	2	*	
				,	Ì
Multipour Number	~	7	7	,	
				•	_

	4	2000	transfer water (Secure Long)	, Light	
Reservoir Temperature	1%	196	81	197	
Cup Temperature	199	199	199	199	
Material Temperature	197	197	195	191	
Time Poured	7:10	7:13	7:19	7.21	
Duration of Pour					
Multipour Number	1	-	-	-	
			4		

	Core	Core Melting Data	Data		
Time Start	7:15	7:18:1	7:18:10 7:24	7:29	
Time Probe Down		7:18:16			
Time Finish	7:17:30	7:17:30 7:20:40	!	7:26:30 7:51:30	
Duration of Pour	220	229	220	"	
Probe Temperature	4	•	4	-	
Probe Unit Number					

TEST CROUP C

		l			
Test Runber	9	9	9	٥	
Pate	9/6/73	9/6/73 9/6/73 9/6/73	9/6/73	9/6/73	
Skid Nurber	s	•	7	80	

Cooling Bay Data

Cooling Ray - Position	3-5	3-8	3	ŕ	
Length of Throud Time	25	25	22	×	
Cooling Roy Temp. Averages					
¥	98	86	86	1	
В	86	98	98	\$	
ပ	83	85	85	20	
D	86	86	98	8	
Bay	06	96	8	8	

X-Rey Results

Number of Shells Poured	59###	09	57.	28**	
Number of Criticals	1	0	٥	٥	
Number of Minors	0	~	•	0	
Number of Cavities	2	1		۰	
Number of Good Shells	58	8	2	95	
Maximum Area of Cavity	49.5	20.5	5	0	
Average Arca of Cavity	49.5	20.5	٥	•	
Hettan Area of Gavity	,		0	•	
Total Area of Cavity	49.5	20.5	0	°	

*Shells 2, 3, and 13 are omitted as they were poured too low to produce a good shell. **Shells 2 and 3 are omitted as they were poured too low to produce a good shell. ***Thells 7 omitted. Low pour.

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ŀ		•		ı
ľ	-	•	ı	

Test Number	7	7	. 7	7	
Date	9/6/73	16/73 9/6/73	۳۲/9/6	9/6/73	
Skid Number	9	10	11	21	

			֟֝֝֟֝֟֝֟֝֟֝֟֝֝֟֩֟֩֟֩		
Reservoir Temperature	174	174	174	174	
Cup Teaperature	178	178	178	178	
Material Temperature	921	177	177	178	
Shell Temperature	08	80	80	08	
Time Poured	8:23	8:25	8:28	8 · 33	
Duration of Pour	7€	34	34	76	
Multipour Number	2	2	2	2	

Multipour Data (Second Pour)

Reservoir Temperature	200	002	200	200	
Cup Temperature	199	199	199	199	
Material Temperature	195	195	195	198	
Time Poured	D:24	8:26	8:29	9:34	
Duration of Pour	•	•		-	
Multipour Number	1	1	1	1	

Core Melting Data

,					-
Time Start	8:29	8:31	8:34	8:39	
Time Probe Down	•	ı	٠	•	
Time Finish	8:29:14	8:31:12	8:31:12 8:34:11 8:39:11	8:39:11	
Duration of Pour	٠	٠	•	•	
Probe Temperature			•	•	
Probe Unit Number	7	7	7	7	

TEST GROUP C

Test Number	7	2	٤	,	
Date	9/6/73	57/9/6 51/9/6 51/9/6 51/9/6	6//9/6	6/6/73	
Skid Number	6	10	11	12	

Cooling Bay Data

Cooling Ray - Position	-7	-7	-7	3-6	
rength of Shroud Thre	/5	75	25	7.5	
Gooling Bay Temp. Averages					
Y	85	85	85	85	
В	78	78	78	78	
S	83	83	83	83	
Q	78	84	78	84	
Вау	88	88	ક	89	

-Ray Results

Number of Shells Poured	5.2	₹# 85	09	09	
Mumber of Criticals	1	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	1	0	0	0	
Mumber of Good Siclis	56	58	09	60	
Maximam Area of Cavaty	•	0	0	0	
Average Area of Cavity	•	0	u	0	
Median Area of Cavity	•	0	•	•	
Total Area of Cavity	29	υ	0	0	

*Shells 2, 5, and 6 omitted. Low pour.

GROUP D PETROLITE WITH 0.1% SPAN 85

Test #	Percent Scrap	Probe
1	0	No
2	40	No
3	40	2.5 minutes
4	0	2.5 minutes
5	70	2.5 minutes

NOTES:

是可能的是是不是的是一个,就是对外的现在分词,是是是不是是,是是一个,我们也不是是是,我们也不是是是,我们也是不是是一个,我们也是不是是一个,我们也会会会会会会 第一个时间,我们也是一个时间,我们也不是一个,我们就是一个时间,我们就是一个时间,我们就是一个时间,我们就是一个时间,我们就是一个时间,我们就是一个时间,我们就

- 1. Single pour.
- 2. Material temperature 176°±2°F.
- 3. Shell temperature $75^{\circ}\pm5^{\circ}F$.
- 4. Core melt to depth of 1 to 2 inches above the break-off point. Start probing at 5+1 minutes after pouring and probe for 2.5 minutes.
- 5. Shroud time 1.25 hours.
- 6. Cooling period 3.75 hours.
- 7. 100% X-ray all shells.
- 8. Use wood shroud.
- 9. 10 skids per test except Test #1 which was 20 skids.

GROUP D DEFECT SUMMARY

Probe Time

% Scrap	No Probe	2.5 Minutes
0	4C 1M	2C 2M
40	<u>2</u>	lm
70	-	<u>5</u> 1M

Table 1 Group D Defect Summary

1	۱	
į	١	
`		,
-		
ŧ		

***************************************		9-10-73 9-10-73 9-10-73 9-10-73	2 4
	1	-73 9-10-7	1 2
	Test Cubor	Date 9-10-	Skid Narber 1 2 3

	ed to the) First Line	Marthant Day (First Four)	r.	
Reservoir Tenporature	176	176 175	174	174	176
Cup Temperature	176	176 176	176	176	176
Haterial Temporature	177	176	174	176	176
Shell Temperature	78	44	77	76	76
Time Poured	5:58	6:01	90:9	6:10	6:38
Duration of Pour	67	35	57	S	57
Multipour Number	,	,	,	,	,

Multipour Data (Second Four)

	un ribo	m Mara	nutripour mara (second tour)	ar)	
Reservoir Tenyarature	•	•	•	,	
Cup Tenperature	1	ı	t		
Material Temperature		1	,	,	,
Time Poured			•	ı	,
Garation of Pour	1	1			,
Multipour Busher	*			1	
*** *** *** *** *** *** *** *** *** **	The state of the s				

Core E Prine Late

Tine Stant	.				'
Time Probe Down	 - -	-		_ <u> </u>	
Tine Finish	· ·			'!	
Durstion of Pour	;	ļ. 	1	;	 ' -
			1	•	•
Property in the				·	

Test Group D

Test Mucher		-1	1	٦	-
Date	P-10-73 9-10-73 9-10-73 9-10-73	9-10-73	9-10-73	9-10-73	9-10-73
Skid Number		2	3	7	3

ing Bore Bota

Cooling Bay - Position	3-1	3-2	3-3	1	ž
Length of Shroud Time	75	7.5	75	25	35
Cooling Bay Tenp. Averages					
V	81	81	18	81	81
æ	81	ij	10	31	81
ပ	8	81	เม	81	81
ú	82	82	82	81	81
Вау	83	83	83	83	23

Sav Board to

number of Shells Foured	×	જ	99	9	9
Mumber of Griticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Harber of Cavities	٥	9	7	0	0
Nurly 1 of Good Shells	59	09	9	9	09
Mulicu Area of Carati	0	С	•	c	7.5
Average free of Courty	0	0	4.5		,
n Area o	0	o	0	0	٥
Total Area of Cavity	0	0	18	0	14
		1			

Shell 37 omitted.

Test Group D

Test Number	1	1	1	-1	-
Date	9-10-73 9-10-73 9-10-73 9-10-73	9-10-73	9-10-73	9-10-73	9-10-73
Skid Number	9	7	80	5	ន្ត

Reservoir Temperature 176 1	174	17%	173	17.2
Oup Temperature 176 1:	176	176	176	176
Material Temperature 176 1	176	175	176	12
Shell Temperature 75	77	2	77 75]
Time Poured 6:42 6:4	971.9	67:9	7:00	3.04
Duration of Pour 45 4	53	43	7	3
Multipour Number 2	2	2	2	2

Multipour Data (Second Pour

	od 17 mu	mr mara (nutripour para (second rour)	Ę	
Reservoir Temperature				·	
Cup Temperature	•	•	•		
Material Temperature	•				
Time Poured		•			
Duration of Pour				•	
Multipour Number					

Cone Welting Bets

Tine Start Tine Probe Dom Tine Finish			• • •		
Duration of Pour	•	•		,	
Probe Temperature	•	•	•		•
Probe Unit Nurber	•!	•	•		

Test Grown D

Cocling Bay Pata

			,			•		
	1,12	35		8	8	8	42	æ
	រុំ	2,5		8	æ	8	22	đ
	7	75		81	8	81	เร	83
,	3-7	75		18	33	81	81	82
	94	75		81	31	88	81	82
	Cooling Bay - Position	Length of Shroud Time	Cooling Bay Temp. Average:	Y	В	ပ	D	Bay

_							
	Number of Shells Poured	09	09	8	g	3	$\overline{}$
	Number of Criticals	-	٥	٥	٥	-	
	Number of Minors	0	0	•	0	0	_
	Number of Cavities	-	0	0		-	-
	Number of Good Shells	65	09	09	9	99	
	Maximum Area of Cavity	•	٥	0		<u>.</u>	·
I	Average Arca of Cavity	•	0			<u> </u>	, .
	Median Arca of Cavity				,	 	
	Total Area of Cavity	35			7.5	\$ 7.	

Test Group D

Test Musber	1	-	4	1	-
Bate	9-10-73	9-10-73 9-10-73 9-10-73 9-10-73	0-10-73	4-10-73	9-10-73
Skid Mumber	11	ฆ	13	71	15

ture 171 171 171 ture 177 177 175 7.17 7.21 7.25 7.17 7.21 7.25 7.17 7.21 7.25 7.17 7.21 7.25 7.17 7.21 7.25 7.17 7.21 7.25 7.22 7.25 7.25 7.25 7.25 7.25	***************************************					
ture 176 176 176 c 77 17 75 7117 7:21 7:25 7 44 45 42	Rescryoir Tenporature	171	171	171	171	172
ture 177 177 177 75 75 75 75 75 75 75 75 75 75 75 75 7	Cup Tenserature	376	176	176	176	120
77 77 75 75 75 75 75 75 75 75 75 75 75 7	Material Temperature	177	177	177		176
7:17 7:21 7:25 7: 44 45 42	Shell Temperature	11	11	75	i	92
27 27 27	Time Poured	i i	7:21		7:30	7:33
Multiponer Number 2 2 2 2	Duration of Pour	73	57	1,2	77	E
y and an analysis of the same	Multipour Number	8	8	7	2	7

	Multipo	ur Data (Multipour Data (Second Pour)	(F)	
Reservoir Temperature				•	
Cup Temperature	•	•	•	•	
Material Temperature	•	•	•	,	
Time Poured	•	•	•		
Duration of Pour	•	•	•		
Multipour Number	•		•		

Core Molting Data

Time Start	•	٠	•	•	•
Time Probe Down	•			•	•
Tize Finish	•		•		•
Duration of Pour	•	•	•	•	•
Probe Temperature	•	•			•
Probe Unit Humber		•	 -	<u> </u>	•

Test Group D

	9-10-73	15
[9-10-72	74
٦	9-10-73	13
1	9-10-73	12
-	9-10-73 9-10-73 9-10-73 9-10-73	11
Tost Ruber	Date	Skad Narber

Cooling Bay Lata

Couling Bay - Position	7	3-12	ĩ	7,17	7
Length of Shroud Time	7.5	75	7,	4	1 2
Cooling Bay Terp. Averages					
Α	88	8	8	8	Ş
В	08	8	8	8	
ပ	86	8	8	8	
D	8	8	8	8	
Bay	83	83	83	89	82

Number of Shells Poured	9	8	ş	\$	5
Number of Criticals	-	٥	~	3	9
Number of Minors	°		0		, ,
Number of Cavities	1	0	-	•	9
Number of Good Shells	59	99	59	09	9
Maxinum Area of Carity	•	0	·		0
Average Area of Cavity			 	0	•
Median Area of Cavity	•	0		٥	0
Total Area of Cavity	31.5	0	25	0	0

•	-	
	•	

Test Number	-	-	-	-	-
Date	9/10/73	9/10/73	57/01/9 57/01/9 57/01/9 57/01/9	9/10/73	6/10//3
Skdd Number	17	18	19	20	12

Cup Temperature 172 172 172 173 173 173 173 173 173 174 175 176 176 176 176 176 177 178						
Eure 176 176 176 176 176 176 176 177 177 178 177 178 177 178 178 177 178 178	Reservoir Tesperature	172	172	172	172	172
Eure 176 176 178 177 e 76 75 75 74 6:22 8:25 8:28 8:31 42 43 42 44 2 2 2 2	Cup Temperature	176	176	176	176	176
6 15 15 75 74 74 75 74 75 74 75 74 75 75 75 75 75 75 75 75 75 75 75 75 75	Material Temperature	176	176	178	177	177
6:22 8:25 8:26 8:31 42 43 42 44 2 2 2 2	Shell femperature	76	75	75	7.6	76
2 2 2 2 2	Thme Poured	8:22	8:25	8:28	8:31	8:35
Multipour Number 2 2 2 2 2	Duration of Pour	42	43	42	77	77
	Multipour Number	7	2	2	2	2

	Multipo	ur Deta (Multipour Data (Second Pour)	(.)	
Reservoir Temperature	•	•	•	•	•
Cap Temperature	•	•		-	•
Material Temperature	•	•	•	•	•
Time Poured	•	•	•	•	•
Duration of Pour	•	•	•	•	•
Multipour Busher	•	•	•	•	•

Time Start	•	•	•	•	•
Time Probe Down	•	•	•	•	
The Pinish	•	•	•	•	•
Duration of Probe	•	•	•	٠	•
Probe Temperature		•	•	•	•
Probe Unit Mumber	•	•	•	•	

Skid Number Date

9/10/73 4/10/73

9/10/73

TEST GROUP D

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		,			
Cooling Bay - Position	4-3	7-7	5-7	9-5	4-7
Length of Shroud Time	7.5	7.5	52	7.5	52
Cooling Bay Temp. Averages				,	
Y	80	80	gr)	80	
æ	•	'	•	•	•
ပ		-	•	•	-
Q		•		•	•
Bay	82	82	82	82	83

The second secon				1	
Number of Shells Foured	09	09	09	09	09
Number of Griticals	0	0	0	0	0
Number of Minors	Q	1	0	0	0
Number of Cavities	0	1	0	0	0
Number of Good Shells	39	65	09	09	09
Meximum Area of Cavity	0	,	0	0	0
Average Area of Cavity	9	•	Ð	0	0
Median Area of Cavity	0	•	۰	0	0
Total Area of Cavity	٥	12.5	6	c	٥

Test Group D

是一种,我们是一个人,我们是一

2 2	0-11-73 0-11-73 0-11-73 0-11-73 0-11-73	. 4
2 2	2-11-73	2
2	0-11-73	7
Test Number	Date	Skid Number

Multipour Data (First Pour)

		(
Reservoir Temperature	175	17.5	174	174	72.0
Cup Temperature	170	179	178	179	179
Material Temperature	176	178	178	177	121
Shell Temperature	78	76	79	76	1.1.
Tine Poured	5:38	5142	5:45	وءنن	6:12
Duration of Pour	7,	36	07	37	%
Multipour Number	2	2	2	2	2

inittenim Pata (Second Pour

	Multipo	ur Data (Multipour Data (Second Pour)	ur)	
Reservoir Temperature	•	-	•	•	
Cup Temperature	•	•	•		-
Material Temporature	•	•	•		,
Time Poured	•	ı	•		
Duration of Four	-	•	•	•	
Multipour Number	١	-	-	•	

	Corc	Corc Melting Data	Data		
Tire Start			•	-	-
Tine Proce Do.m	•		•	- T	
Tíre Finísh	,	•	.	<u>'</u>	-
Duration of Pour	,	•			,
			•		•
Probe line traker	_				

EST GROUP D

Test Number	2	2	2	2	2
Date	9/11/73	9/11/73 9/11/73 9/11/73 9/11/73	9/11/73	9/11/73	5/11/8
Skid Number	-	2	3	7	٠

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3=4	3-8
Length of Shroud Time	75	7.5	75	7.5	?
Cooling Bay Temp. Averages					
Y	83	83	83	84	98
В	84	84	78	84	84
ວ	32	82	82	83	83
a	84	97	98	84	84
Вау	98	98	98	87	28

Number of Shells Poured	90	60	90	99	Ŋ
Number of Criticals	ú	ű	0	0	ď
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	ď
Number of Good Shells	09	09	09	09	09

Test Group D

Test Number	2	2	2	2	~
Date	9-11-73	11-11-	9-11-73	9-11-73 +11-73 9-11-73 9-11-73	9-11-73
Skid Number	b	7	∞	0	g

Renervolr Temperature	. 174	174	721	9/1	176
Cup Temperature	179	41	17c	176	176
Material Temporature	177	177	176	176	176
Shell Temperature	75	78	11	11	22
Time Poured	6:16	6:20	6:23	6:57	7:01
Duration of Pour	37	37	37	9	8 2
Multipour Mumber	2	8	2	2	2

Multipour Data (Second Pour)

	Del to train	E MICH	merethon wird (Second Long)	È	
Reservoir Temperature		•		:	•
Cup Temperature	•	•			-
Material Temperature	,	,	•	•	
Time Poured	•	'	,		
Duration of Pour	•				
Multipour Number		•			•

Core Helting Data

Dona Guran					•	,
	Time Start	Time Probe Down,	Tire Finish	Duration of Per	Probe Temperature	Probe Unit Number

TEST GROUP D

Test Number	7.	2	2	2	~
Date	51/11/6	8/11/9 81/11/9 81/11/0 81/11/9 81/11/9	6/11/9	67/11/6	67/11/6
Skid Number	9	۷		۰	01

Cooling Bay Late

Cooling Bay - Position	۶	[•	
interest for Guerran	î	07-5	11-5	1-7	4+2
Length of Shroud Time	7.5	2	25	\$4	,
Cooling Bay Temp. Averages					;
٧	83	83	83	18	1.8
æ	83	83	£3		
ပ	82	82	83		
Q	78	84	7,0		
Вау	98	445	86	85	85

Number of Shells Poured	99	09	9	9	9
Number of Criticals	0	o	0	0	۰
Number of Minors	0	U	0	c	0
Number of Cavities	0	υ	د	Ú	0
Number of Good Shells	60	09	09	90	09

- NOTES:
 1. On Skid 10 the crystallization and porosity was heavier than in the previous skids of this test, and had some small stringers.
 - Skid had very heavy porosity and crystallization with some small stringers under the fuze well.

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GROUP
8
TEST

Test Numbir	3	3	٤	3	3
Date	6/11/23	6/11/3	9/11/73 9/11/73 9/11/73 9/11/73	62/11/6	62/11/6
Skid Munber	11	12	13	71	2

Reservoir Temperature	176	176	9/1	176	176
Cup Temperature	176	176	176	3.76	176
Material Temperature	941	176	1 76	176	176
Shell Temperature	"	77	78	7.8	"
The Poured	7.04	7:09	7.17	7:23	7:40
Duration of Pour	96	×	37	35	'n
Multipour Number	2	2	~	2	

	Multipo	ur Data (Multipour Data (Second Pour)	(F)	
Reservoir Temperature	٠	•	·		
Oup Temperature	•	•	•	•	•
Material Temperature	•		٠	•	
Time Poured	-	•	•		-
Duration of Pour	•	. •		٠	
Multipour Musber	•	•	•		

Core Welting Data

Time Start				
	7.09 7:1	7:14:15 7:22	7:28	9:45
Time Pribe Down 7:09:08	- 80:	7:22:07	•	9:45:06
Time Firstsh 7:11:	7:11:30 7:16:45 7:24:30 7:30:30 9:47:30	7:24:30	7:30:30	9:47:30
Duration of Probe 2.5	\$77	\$2	2.5	2.5
Probe Temperature 223		225	220+5	227
Probe Unit Number 3	7	,	4	-

TEST CROUP D

Test Number 3	,	3	l.	-
Dete 9/11/7	9/11/73 9/11/73 9/11/73 9/11/73	8/11/3	9/11/73	14/11/9
Skid Number 11	12	13	14	15

Cooling Bay Data

Cooling Bay - Fasition	3-12	4-3	3-13	7-7	3-14
Length of Shroud Time	7.5	2,2	2,2	2,2	2
Cooling Bay Temp. Averages					
Ą	82	18	82	81	ä
В	83	•	83		6
ပ	82	•	28		:
Q	83		83		:
Bay	88	85	88	5	a

Number of Shells Poured	9	9	97	ļ	
		3	2	8	9
Number of Criticals	0	0	•	0	o
Number of Minors	0	J	0	o	
Number of Cavities	0	9	5	, ,	
Number of Good Shells	09	60	, 5		3

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يم	
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fest Musber	-		~	_	-
Date	8/11/73	9/11/73	5711/9 57/11/9 57/11/9 57/11/9	6/11/6	9/1773
Stid Musber	91	21	81	61	02

	Multipo	ur Data (Multipour Data (First Four)		
Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	176
Material Temperature	176	177	177	176	176
Shell Temperature	76	76	75	2,6	75
Time Poured	7:44	1 49	7:52	7:57	8:03
Duration of Pour	37	34	35	67	35
Multipour Number	2	~	2	2	2

	Multipo	ur Data (Multipour Data (Second Pour)	(4)	
Beservoir Teaperature	•	-	•	-	•
Cup Temperature	-	•	•	•	•
Material Temperature	•	•	•	•	•
Time Poured	•	•	•	•	•
Duration of Pour	٠	•	•	-	•
Multipour Marber		•	•	•	•

Core Mclting Data

Time Start	7:49	7:54	7:57	7:57 8:02 8:02	8:07
Time Probe Down	•	7:54:05		•	٠
Time Finish	7:51:30	7:56:30	7:51:30 7:56:30 7.59:30 8.05:30 8:09:30	8.05:30	8:09:30
Duration of Probe	2.5	5,5	2.5	2.5	2.5
Probe Temperature	•		•		•
Probe Unit Number	7	ì	7	3	7

TEST GROUP D

Test Number	3	3	3	3	3
Date	8/11/73	6/11/73 9/11/73 9/11/73 9/11/73	9/11/73	9/11/73	9/11/73
Skid Number	91	41	81	61	20

Cooling Bay Data

Gooling Bay - Penition	4-5	3-5	9-7	3-6	4-7
Length of Shroud Time	7.5	75	7.5	52	7.5
Cooling Bay Temp. Avera 's					
Υ	81	82	80	18	80
æ	-	81	•	81	٠
	-	90	•	80	
Q	•	82	•	82	1
Вау	78	85	78	85	8

Number of Shells Poured	60	09	09	09	09
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	l	0	٥
Number of Cavities	0	0	1	0	0
Number of Good Shells	09	09	65	09	09

2
4
ž
•

Test Marber	7	7	4	.7	7
Date	9/12/73	9/12/73	5/12/73 9/12/73 9/12/73 9/12/73	81/21/6	9/12/73
Skid Mumber		2	3	7	\$

	Multipo	ur Data (Multipour Data (First Pour)	£	
Reservoir Temperature	174	174	175	174	174
Cup Temperature	180	179	179	180	180
Material Temperature	176	177	176	176	177
Shell Temperature	78	79	79	79	92
Time Poured	5:48	\$ - \$2	5:55	6:00 6:03	6:03
Duration of Pour	41	41	42	44	41
Multipour Number	2	2	2	2	2

Multipour Data (Second Pour)

	oden mu		/ winner moderanu		
Reservoir Temperature	•	•	•	•	
Cup Temperature	•	•		•	a
Material Temperature	•	•	•	•	•
Time Poured			•	٠	
Duration of Pour	•	1	•	•	•
Multipour Mumber	•	•	•		•

Come Maltino Date

	9	TOTAL STATE OF THE			
Time Start	5.53:00	5 53:00 5:57	90:9	6:05 6 08	6 UB
Time Frobe Down	•	•		•	•
Time Finish	5:55:30	3:55-30 5:59:30 6:02:30 6:07:30 6:10:00	6:02:30	6:07:30	6 · 10 : 00
Duration of Probe	2.5	2.5	2.5		2.5 2.0
Probe Temperature	221		221	•	•
Probe Unit Number	2	,	2	7	3

ST CROUP D

是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们

Test Number	1	7	7	9	7
Date	9/12/73	9/12/73 9/12/73 9/12/73 9/12/73 9/12/73	9/12/73	9/12/73	9/12/73
Std Amber	1	2	3	7	s

Cooling Bay Erta

Cooling Bay - Position	3-1	71-7	7-8	1-4	7-9
Length of Shroud Time					
Gooling Bay Temp. Averages					
Y	26	78	84	78	78
æ	83	•	83	-,	•
C	83	٠	82		•
Q	83	•	85	•	•
Bey	87	87	87	87	49
<u> </u>					

Mumber of Shells Poured	90	60	60	60	09
Mumber of Criticels	0	0	0	1	0
Mumber of Minors	0	0	0	0	٥
Mumber of Cavitins	0	0	0	1	0
Minches of Good See 18	09	9	9	60	8

Test Number	4	7	4	7	7
Date	9/12/73	-1/21/6	57,21/9 57,21/9; -7,21/9 57,21/9	9/12/73	8/12/73
Skid Number	6	7	8	6	01

	The state of the s				-
Reservoir Temperature	175	175	174	175 174	174
Cup Temperature	180	180	180	180	180
Material Temperature	177	177	177	177 178	178
Shell Temperature	62	96	79	79	11
Time Poured	6:07	6.11	6:15	6.19 6.23	6.23
Duration of Pour	3	33	38	à	86
Multipour Number	٠,	۲.	~	~	_~~_

	mot worse some moderne				
Reservoir Temperature	•			•	
Cup Temperature	•	•	•	•	
Material Temperature	•	٠	•	•	•
Time Poured	•	5	•	٠	•
Duration of Four	•	•	•	٠	•
Multipour Musber	•	٠	•	•	

Core Melting Data

Time Start 6 12 6 16 6 26 6 26 6 28 6 28 73 6 28 73 6 28 73 6 28 73 6 10 10 10 10 10 10 10 10 10 10 10 10 10			200			
	Time Start	6 12	6 16 C	25 9	72 0	6 28
	Time Probe Down	•	,	•	•	•
2.5 2.5 2.5 2.5	Time Finish	6:14.3	6:18:30	6: 22: 30	6.26:30	6 30 30
Probe Temperatur:	Duration of Probe	2.5	2.5	2.5		2.5
Probe Unit Number 4 3 4 3 4	Probe Temperature	•	•	•	•	•
	Probe Unit Number	7	3	7	3	7

Test Number	7	7	7	7	7
Date	5/12/73	9/12/73 9/12/73 9/12/73	6/121/6	9/12/73 9/12/73	9/12/73
Stid Number	9	۷	80	6	2

Cooling Bay Data

Cooling Bay - Position	6-7	3-3	7-7	7-6	Ş.
Length of Shroud Time					
Cooling Bay Temp. Averages					
Y	78	78	78	84	78
В	•	83		83	ŀ
၁	•	82	•	82	
D	•	8		85	
Bay	87	87	87	87	8

Number of Shells Poured	09	90	09	9	9
Number of Criticals	0	ı	0	٥	0
Number of Minors	0	0	-	1	0
Number of Cavities	0	1	-	ı	0
Number of Good Sugl1s	93	59	59	65	ç

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Test Mumber	\$	5	\$	5	\$
Date	81/21/6	9/12/73	6/12/73 9/12/73 9/12/73 9/12/73 9/12/73	9/12/73	6/12//9
Skid Number	11	21	13	71	\$1

Multipour Data (First Pour)

Reservoir Temperature	172	174	172	172 180	180
Cup Temperature	182	182	182	182 179	179
Material Temperature	176	176	176	178 176	176
Shell Temperature	77	75	76	9,6	72
Time Poured	7:08	7:12	7:16	7:20 2:34	2:36
Duration of Pour	07	39	34	33	33
Multipour Number	1	1	1	ı	2

Multipour Data (Second Pour)

Reservoir Temperature				
		•	•	•
Cup Temperature		•	•	•
Material Temperature		٠	۰	•
Time Poured	•	•	•	•
Duration of Pour		•	٠	•
Multipour Musber -		•	•	•

Core Melting Data

Time Start	7:13	7:17	7:21	7:25 2:39	2:39
Time Probe Down		•			
Time Pinish	7:15	7:19:30	7:19:30 7:23:30 7:23:30	7:27:30	7:41:30
Duration of Probe	2.5	2.5	2.5	2.5	\$ 6
Probe Temperature	•	•		•	
Probe Unit Number	3	7	3	4	

EST GROUP D

Test Marber	\$	•	3	3	۶
Date	9/12/73	9/12/73 9/12/73 9/12/73 9/12/73	9/12/73	8/12//3	9/12/73
Srid Number	11	12	13	36	15

Cooling Bay Drite

Graiing Bay - Position	3-14	11-7	3-13	9-5	3-12
Length of Shroud Time					
Cooling Bay Temp. Averages					
*	82	28	82	82	83
æ	82	•	62	•	6 2
ຍ	18		81	•	19
Q	83		83	•	83
Beg	3	2	38	98	*

"L-Rey Results

Mumber of Shells Poured	9	9	90	09 09 09	S
Mumber of Criticals	0	0	0	0	
Mumber of Minors	٥	0	0	0	0
Number of Cavities	0	0	0	0	0
	09	09	9	ş	8

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Test Mumber	5	,	5	3	\$
Date	9/12/73	9/12/73 9/12/73 9/12/73 9/12/73	9/12/73	6/12//9	9/12/73
Skid Mumber	91	17	18	61	20

Reservoir Temperature	176	175	173	172	172
Cup Temperature	178	178	180	180	180
Material Temperature	176	176	177	7.1	178
Shell Temperature	77	77	79	7.7	7.5
Time Poursd	7:38	7-43	8.02	8 06 8 11	B · 1.1
Duration of Pour	37	38	38	37	35
Multipour Number	2	7	2	2	

ultipour Data (Second Four)

	2		יייי איייי איייי איייי אייייי אייייי איייייי	,	
Reservoir Temperature	•	•	٠	•	
Cap Temperature	•	•	٠	٠	•
Material Temperature	•	•	•	•	•
Time Poured	٠	-	•	•	•
Duration of Pour	•	•	•	•	•
Multipour Musber	•	•		•	•

Core Melting Data

Time Start 7:43 7.48 8:07 8:11 8:16 Time Probe Domn -						
	Time Start	7:43	7.48	8:07	8:11	1:16
	Time Probe Down	•	•	•	•	
2.5 2.5	Time Pinish	7:45:30	7: 50: 30	8:09:30	8:13:30	8 · 18 · 30
Trube Temperature	Luration of Probe	2.5	2.5	2.5	2.5	5.
Probe Unit Number 4 3 4	Trobe Temperature			•	•	
	Probe Unit Number	7	3	7	3	7

C diamen 15:

Test Number	5	5	5	5	\$
Date	9/12/73	9/12/73 9/12/73 9/12/73 9/12/73	9/12/73	9/12/73	9/12/73
Skid Number	16	17	18	19	20

Cooling Bay Data

Shroud Tine 7 Temp, Averages 82 83 83 7 82 - 81 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Cooling Bay - Position	4-7	3-11	61-7	3-10	7-10
82 83 63 63 64 64 64 64 64 64 64 64 64 64 64 64 64	Length of Shroud Time					
82 83 83 - 81 81 81 81	Cooling Bay Temp. Averages					
- 62	A	82	83	83	82	81
- 831 -	æ	•	82	•	81	,
- 83 -	ບ	•	· 18	•	18	٠
, co	Q	•	68	•	82	
70	Buy	85	98	8.	\$\$	26

Number of Shells Foured	60	9	9	60	99
Number of Criticals	0	0	0	0	0
Mumber of Minors	0	0	0	0	0
Number of Cavities	0	0	υ	0	o
Number of Good Shells	09	09	09	9	09

GROUP E PETROLITE

Test #	Number of Skids	Material Temperature	Steel Temperature	Percent Scrap	Nominal Probe Time <u>Minutes</u>
1	11	175-177	75-78	0	0
2	10	175-178	75 - 78	0	2.5
3	10	175-176	70-71	40	0
4	11	175-177	68-74	40	2.5
5	10	175-179	72 - 75	0	0
6	12	175-178	72-75	70	0

NOTES

- 1. Single pour.
- 2. The core melt depth was 1 to 2 inches above the break-off point. Probing was started 5+1 minutes after pouring.
- 3. Shroud time was 1.25 hours.
- 4. The total cooling period was 3.75 hours.
- 5. The Picatinny shroud and baffle were used.

GROUP E DEFECT SUMMARY

Probe

% Scrap	No	2.5 minutes
	1,	5 2
o	0	0
	3	3 4
40	0	0
	[6	
70	0	-

•			
		2	
		ì	
		٠	•
	ĺ	۱	

Test Mumber	1	1	; -	1	1
Date	K-13-73 0-13-73 G-13-73 U-13-73 Q-13-73	0-13-73	9-13-73	u-13-73	9-13-73
Skid Number	~	٧	~	4	۰

	Kultipo	ur Deta (Kultipour Data (First Pour)	E)	
Reservoir Temporature	174	721	174	121	175
Cup Temperature	176	178	174	179	130
Material Temperature	175	175	175	17.5	176
Shell Temperature	75		76	76	92
Time Poured	5:14	5:20	5:32	5:35	5:35
Duration of Four	'	4.5	45	4.5	73
Multipour Number	. 2	8	2	8	2

	(
Reservoir Temperature	•	•	•	•	•
Cup Temperature	-	•	•	-	•
Material Temperature	-	•		•	•
Time Poured .	•		•	•	•
Duration of Pour	-	•	•	•	٠
Multipour Number	•	•	•	•	•

		More and the second	H		
Time Start	•	•	-		•
Time Probe Down	-	•	•	,	٠
Time Finish	•	•	•	-	•
Duration of Probe	•	-	•	•	•
Probe Temperature		•	•	•	•
Probe Unit Number		•	,	•	1

Test Number	•	1	1	1	1
Date	6/13/73	9/13/73 9/13/73 9/13/73 9/13/73	9/13/73	9/13/73	9/13/73
Skid Number	1	2	3	7	۶

Cocling Bay Data

Cooling Bay - Position 3-1	-1	3-2	3-3	4-11	34
Length of Shroud Time	1:15.	1:15	1:15	1:15	1:15
Cooling Bay Temp. Averages					
A 83	~	83	83	931	84
83		83	83	•	83
ft8 .	<u>z</u>	84	84	•	84
S8 0		84	85		84
Bay 87		87	87	98	87

Number of Shells Poured	09	09	09	09	09
unber of Criticals	O	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Minhon of Good Shalls	09	09	09	09	9

TEST GROUP E

Test Matter	7	-	-	-	-
Date	9-13-73	9-13-73	9-13-73 9-13-73 9-13-73 9-13-73 0-13-73	9-13-73	0-13-73
Skid Mumber	9	7	80	٥	ន

Multipour Data (First Pour)

	•			•	
Reservoir Temperature	176	176	176	176	9Lt
Cup Temperature	178	177	178	177	121
Material Temperature	175	541	175	175	275
Shell Temperature	44	92	4	77	11
Time Poured	5:42	5:55	5:58	6:01	6:05
Duration of Pour	43	77	43	777	77
Multipour Number	2	2	8	2	2

Multipour Data (Second Pour)

	•	•			
Reservoir Temperature	•	•	•	•	
Cup Temperature	•	•	•	٠	
Material Temperature	-	•	•		•
Time Poured	-	•	•	•	٠
Duration of Pour	-	-	,		
Multipour Mimber	-	•	ı	-	

Core Melting Data

Time Start	•	•	•	•	
Time Probe Down	•	•	•	-	•
Time Finish	•	-	•	•	•
Duration of Probe	•	•	•	-	•
Probe Temperature	•	-	•	•	•
Probe Unit Number	•	•	•	•	•

EST CROWD F

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Wind Market					
rear warner.	-	-	-	-	-
Date	9/13/73	9/13/73 9/13/73 9/13/73 9/13/73 9/13/73	9/13/73	9/13/73	9/13/73
Skid Number	9	۷	80	6	2

Cooling Bay Data

Cooling Bay - Position	3-14	3-13	3-12	3-11	71-7
Lerth of Shroud Time	1:15	1:15	1:15	1:15	1:15
Cooling Bay Temp. Averages					
A	78	83	83	83	78
В	83	82	83	83	
3	83	.78	78	7,8	
D	83	83	83	83	
Bay	87	67	87	8	87

X-Ray Results

Number of Shells Poured	60	9	9	9	90
Number of Criticals	0	0	0	٥	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	o
Number of Good Shells	09	09	9	09	99

sition Time Test Number Skid Number Date Multipour Data (First Pour) TEST CROUP E 172 ส 177 Reservoir Temperature Cup Temperature Test Number Skid Number

Cooling Bay Data

1-13

82

84

TEST GROUP E

9/13/73

23

Material Temperature	177			Cooling Bay - Fre
Shell Temperature	82		I	Length of Shroud
Time Poured	7:32			Cooling Bay Temp.
Duration of Pour	73			٧
Multipour Number	~			В
			1	ບ
	Multipour Data (Second Pour)	(Second Pour)		Ω
Reservoir Temperature	•			Bay
Cup Temperature			- 	
Material Temperature	•			
Time Poured				Number of Snells
Duration of Pour	•			Number of Critical
Multipour Number	-			Number of Minors
			- I	

	K-Ra	X-Ray Results	
Number of Snells Poured	09		
Number of Criticals	0		
Number of Minors	0		
Number of Cavities	0		
Number of Good Shells	90		

Core Melting Data

Duration of Probe Probe Temperature Probe Unit Number

Time Probe Down

Time Start

	100				
Test Musber	2	2	2	2	2
	5/13/73	9/13/73	8/13/13 8/13/13 8/13/13 8/13/13 8/13/19	5/13/73	9/13/73
Stdd Washer	=	12	13	71	15

TEST CHOUP E

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Test whoer					
ukte	5/13/73	8/13/19 8/13/13 8/13/19 8/13/19	9/13/73	9/13/73	8/13/73
Sidd Number	11	12	13	2	22
	Multipo	Multipour Deta (First Pour)	First Pou	н)	
Reservoir Temperature	177	175	175	175	175
Oup Temperature	196	178	178	178	13
Material Temperature	175	175	175	175	176
Shell Temperature	9/	11	22	2	2
Time Poured	60:9	6:42	6:51	6.54	6:57
Duration of Pour	4.5	4.5	3	3	77
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	7	7	7	2	2

Reservoir Temperature Cup Temperature Material Temperature Time Foured Duration of Four						
Reservoir Temperature		Multipo	ur Data (Second Po	(Jn	
Cup Temperature Material Temperature Time Foured Duration of Four	Reservoir Temperature	-	,		•	
Material Temperature Time Foured Duration of Four	Cup Temperature	<u> </u>	٠	,	•	٠
Time Foured Duration of Four	Material Temperature	<u>.</u>	,	٠	•	•
Duration of Four	Time Poured	·		•	,	•
Mail et course Plancher	Duration of Pour	-		,		•
	Multipour Ember			-	٠	•

X-Ray Results

8

Number of Shells Poured

Number of Criticals

0

9

Number of Good Shells

Number of Cavities Number of Minors

Time Poured		•	•	•	•
Duration of Pour		•	•	,	
Multipour Ember	-	•	-	•	
	Core	Core Melting Data	Deta		
Time Start	6:15	6:47	6:56	6:39	7:02
Type Probe Down	<u>.</u>	•	•	ı	•
Time Findsh	6:17:30	6:17:30 6:49:30	6:58:30 7:01:30	7:01:30	7:04:30
Duration of Probe	2.5	2.5	2.5	2.5	2.5
Probe Temperature	227	122	•	227	
Darche Intt Number	3	3	7	3	7

Test Number	2	2	2	2	7
Date	9/13/73	9/13/73	9/13, 73	9/13/73	9/13/73
Skdd Number	11	12	13	14	15
	Cool	Cooling Bay E-ta	g a		
Cooling Bay - Position	4-10	3-11	4-13	3-10	71-7
Length of Shroud Time	1:15	1:15	1:15	1:15	1115
Cooling Bay Temp. Averages					
Y	83	84	82	78	82
æ	•	83	•	82	•
ပ	-	78	•	82	•
Q	•	83	•	83	
Bay	8	88	78	98	84

TEST CHOUP E

Test Murber	2	2	2	2	7
Date	9/13/73	9/13/739/13/73	9/13/73 9/13/73 9/13/73	61/61/6	9/13/73
Skid Mumber	16	17	81	61	20

Multipour Data (First Pour)

Reservoir Temperature 174 174 172 172 173 174 175 177 177 177 177 177 177 177 177 177 178						
### 177 177 177 177 177 177 177 177 176 17	Reservoir Temperature	174	7/1	176	172	661
### 176 178 177 176 176 177 176 176 177 178 179 179 179 179 179 179 179 179 179 179	Cup Temperature	771	177	133	177	1 5
**Ture 77 75 77 78 Pour 44 43 43 42 **Inber 2 2 2 2	Material Temperature	176	178	177	1.7%	1 5
Pour 44 43 43 42 Aber 2 2 2 2	Shell Temperature	77	7.5	"	82	7
2 2 2 2 2	Time Poured	7:01	7:06		7.26	3.30
Multipour Number 2 2 2 2	Duration of Pour	77	43	L	77	17
	Multipour Mumber	2	2	2	2	2

Multipour Data (Second Pour)

Sasarvoir Temperature				
Cup Temperature Material Temperature Time Poured	resperature -		,	•
Material Temperature Time Poured	time -			
Time Poured	emperature	,		
	•			
Duration of Pour	? Pour			
Multipour Munber	funber			

Core Melting Data

Time Start	7:06	7:11		7:28 7:31	7.34
Time Probe Down	•				
Time Finish	7:08:30	7.13:30	7:08:30 7:13:30 7-30 30 7:33:30 7:36:30	7:33-30	7 · 36 · 30
Duration of Probe	2.5	2.5	2.5	, ,	,
Probe Temperature	330			225	
Probe Unit Number	3	7	ļ _	7	7

TEST GROUP E

Test Number	2	2	7	2	[
Date	67/11/19	6/13/73	6/13/73	9/.3/73 9/.3/73 9/.3/73 9/.3/73	27/51/6
Skid Number	16	17	18	61	95

Cooling Bay Data

	j				
Cooling Bay - Position	3-9	71-7	3-5	3-	6-7
Length of Shroud Time	1.15	1.15	1.15	1.15	L
Cooling Bay Temp. Averages					
A	84	82	78	78	2
В	82	,	83	8	
S	8,		83	82	
D	83		78	8	
Вау	87	78	87	87	85
					_

-Ray Results

Number of Shells Poured	09	*65	09	*65	9
Number of Criticals	c	٥	0	0	٦
Number of Minors	0	0	°	0	°
Number of Cavities	0	0	0	٥	0
Number of Good Shelln	99	65	09	59	9
Maximum Area of Cavity					
Average Area of Cavity					
Median Area of Cavity					
Total Area of Cavity					

*Shell 54 omitted.

2 1831

E 3 9/17/73

TEST CROUP TEST NUMBER TEST DATE

Test Mumber	3	3	3	3	•
Date	9-17-73	9-17-73	9-17-73 9-17-73 9-17-73 9-17-73	5-72-73	9-17-73
Skid Number	9	7	9	6	ន

Aultipour Date (Pirst Pour)

Reservoir Temperature	170	zże	276	178	F
Oup Temperature	375	376	176	176	726
Material Temperature	176	275	326	776	726
Shell Temperature	20	٤	n	n	٤
Time Poured	6102	6105	6106	11.9	\$1.19
Duration of Pour	9	77	9	39	8
Multipour Number	٠.	~	~	ผ	8

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5.44

Time Poured

Duration of Pour Hultipour Number

2

176

179

179

Reserve ir Townerature

Material Temperature Shell Temperature

Cup Temperature

Multipour Date

Multipour Data (Second Pour)

Reservoir Temperature	٠	•	•	•	•
Cup Temperature	•	•		٠	•
Material Temperature		•	•	•	•
Time Poured	•	•	•	•	•
Duretion of Pour	-	٠	•	•	•
Multipour Mumber	•	,	•	•	•

Core Melting Data

Time Start	•	•	•	•	•
Time Probe Down	•	•	•	•	•
Time Finish	•	•	•	•	•
Duration of Probe	•	-	1	-	•
Probe Temperature		•	•	•	•
Probe Unit Number	•	•	•		•

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-6	5-C
Length of Shroud Time	7.5	7.5	75	7.5	7.5
Average Cooling Bay Temp.	77	77	11	11	11

- Nay Results

Number of Shelle Foured	60	90	9	09	9
Number of Criticals	0	0	0	0	٥
Number of Minore	0	0	0	0	0
Humber of Cavities	0	0	0	0	0
Number of Good Shells	60	09	99	60	09
Number of Shells with Porceity & crystallisation	0	0	0	0	0

ROUP F
TEST G

Test Number	ĵ	^	_	_		
Oate	6/11//9	9/17/73 9/17/73 9/17/73	9/17/73	0/17/73	9,17/21	
Skis Number	٩	7	20	•	0.7	

	1000	cooring tany para	313		
Cooling Ray - Festtion	11.	1			
Length of Shroud Time	ž	-			
Gooling Ray Temp. Averages			2	- 13	1:15
A	۲۶	7.5	۲,	74	77
æ	\$2	\$1	ź		
			,		,
ပ	74	7,4	7.7	•	•
Q	7.4	7.5	2		
Вау	*	"	2	92	2

X-Ray Results

Number of Shells Poured	90	09	58*	29**	58800
Number of Criticals	0	0 .	0	o	-
Number of Millots	3	9	5	0	9
Number of Cavities	0	o	۰	0	3
Number of Good Shells	60	09	88	ž	2

TEST CROUP E

Test Number	7	7	7	7	7
Date	9/17/73	9/17/73	8/17/13 9/17/73 9/17/73 9/17/73	8/11/73	8/11/6
Skid Number	11	12	13	71	22

Multipour Data (First Pour)

Reservoir Temperature	176	177	441	178	178
(up Temerature	178	178	841	178	\$
Material Temperature	175	175	176	175	2,2
Shell Temperature	22	89	ıı	69	۶
Time Poured	6:47	25 9	6:55	7:03	7:12
Puration of Pour	55	70 sec	\$\$	67	85
Multipour Number	. 2	2	2	, 2	~

Multipour Data (Second Pour)

Reservoir Temperature	•	;			
Cup Temperature	•	,			•
Material Temperature		•	-		
Time Poured	•	٠	-	,	
Duretion of Pour					
Multipour Number	•				

Core Melting Data

	-				
Time Start	6:52	6:57	6:57 7:00	7:10 7:17	7:17
Time Probe Down	•	•			
Time Finish	6.54:30	6:59:30	6.54:30 6:59:30 7:02:30 7:13:00 7:19:30	7:13:00	7:19:30
Duration of Probe	2.5	2.5	2.5	3.0	2.5
Probe Temperature	224				
Probe Unit Number	3	7	,	4	-

^{*}Shells 3 and 5 omitted, **Shell 55 omitted, ***Shells 6 and 60 omitted,

Test Mumber	,	4	4	7	4	
Date	6/17/73	6/17/73 9/17/73	8/17/73 8/17/73 8/17/73	8/11/13	8/17/73	
Skid Musber	11	12	13	14	21	

	7005	COOLING Bay Erta	3		
Cooling Bay - Position	3-10	£-3	3.10	777	[
Length of Shroud Time	1:15	1:15	_	1:15	ž
Cooling Bay Temp. Averages					<u> </u>
*	7.6	7.3	76	7.3	×
æ	\$2	•	9,6		*
O	74	.,	22		7.
D	75		2		2
Bey	2	"	"	"	1

X-Ray Results

Mumber of Shells Poured	3	ş	:		
		3		إ	9
Number of Criticals	0	•	c		,
Mumber of Hinors	0	•	٥	c	•
		l L			1
Mumber of Cavities	0	•	•	0	_
Mumber of Good Shells	88	9	59	20	9

TEST CHOUP E

Test Mumber	7	7	7	7	7
Date	81/21/6	6/11/6	8/17/19 8/17/19 8/17/19 8/17/19	67/71/6	67/71/8
Skd Mumber	16	17	18	61	2

Multipour Data (First Pour)

Reservoir Temperature	178	178	178	178	178
Cup Temperature	178	178	178	178	178
Material Temperature	175	175	176	921	177
Shell Temperature	70	11	71	71	7
Time Poured	7.11	7:15	7:20	7:23	7:28
Duration of Pour	53	75	87	٤%	æ
Multipour Number	. 2	÷	2	2	~

Multipour Data (Second Pour)

Reservoir Temperature	ı	•	,	•	l.
Cup Temperature		•		•	
Material Temperature	•				
The Poured		,	•		
buration of Pour					
Multipour Musber		•	•	,	,

Core Melting Data

Time Start	7:16	7:20	7:25	7:25 7:28 7:33	7:33
Time Probe Down		•	•		
Time Finish	7:18:30	7:22:30	7:18:30 7:22:30 7:27:30 7:30:30 7:36:30	7:30:30	7:36:30
Duration of Probe	2.5	2.5 2.5	2.5	2.5	, ,
Probe Temperature					
Probe Unit Number	7	3	4	3	4

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GROUP
EST

Test Number	4	7	7	7	3
Date	57/71/9 57/71/9 57/71/9 57/71/9 57/71/9	67/11/6	6/17/73	8/17/73	6/11/6
Std Number	16	41	81	61	Q

	C001	Cooling Bay Data	t a		
Cooling Bay - Puitton	4-5	-	71-7	3-5	9-7
Length of Shroud Time	1:15	1:15	\$1:15	1:15	1:15
Cooling Bay Temp. Averages					
¥	7.3	92	73	76	72
æ	•	76	-	9/	,
ບ	•	7.4		74	
D	•	76	•	9,6	
Rey	11	7.8	"	82	"
				,	

X-Ray Results

Number of Shells Poured	9	09	9	09	09
Number of Criticals	0	Ü	O	0	0
Mumber of Minors	0	C	υ	o	٥
Number of Cavities	0	0	0	c	0
Number of Good Shells	60	09	09	09	ફ

TEST CHOUP &

9/17/73	Test Number 4 Date 9/17/ Sidd Number 21
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Multipour Data (First Pour)

Reservoir Temperature	178	
Cup Temperature	178	
Material Temperature	27.5	
Shell Tesperature	00	
Time Foured	7:32	
Duration of Pour	38	
Multipour Number	2	

		/	ì	
Reservoir Temperature	٠			
Cup Temperature	•			
Material Temperature	-			
Time Poured	•			
Duration of Pour	•			
Multipour Number	•			

Time Start	2 37		
Time Probe Down	•		
Time Finish	7:39:30		
Duration of Probe	2.5		
Probe Temperature			
Buche Hedt Buchen			

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١	ĺ	ì	ı
i	ì		į
٠		Ī	
1	į		١
ì	į		
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			fact Market	S	~	~	S	~	
	TEST GROUP E		TO THE PARTY OF TH	10,00	11/81/0	67,01,0			
Г	7		Date	2) (6) (2)	27.101.72	2/ 10/ /2	2/ /01 /2	2/01/2	
T			Skid Number		2	c	7	\$	
•	82/21/								

Test Number

Skid Number

Multipour Data (First Pour)

Cooling Bay Data

3•6 1:15

Gooling Bay - Position Length of Shroud Time 2

a 0

2 2 2

92

Cooling Bay Temp. Averages

771 771	177
_	
	178
175 176	178
73 72	72
5:35 5:30	5 5:39
47 47	77
, 2	2

Multipour Data (Second Pour)

	No.	1	(mo: repose) som modramu	(1	
Reservoir Temperature	•		•	•	•
Cup Temperature	•	•	•	•	•
Material Temperature	•		•		•
Time Poured	•	•	•	•	•
Duration of Pour	•	•	•	•	•
Multipour Number			•	•	•

X-Ray Results

8

Number of Shells Poured

Number of Criticals

c

3

Number of Good Stells

Number of Minors Number of Cavilles

Core Melting Data

			֡֝֜֝֜֜֜֜֜֝֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֜֓֓֡֓֜֜֜֜֜֡֡֡֓֜֜֡֡֡֡֓֜֜֡֡֡֡֡֡		
Time Start	•		•	•	•
Time Probe Down	•	•	•	•	•
Time Finish	•	•		•	•
Duration of Probe		•	•	•	•
Probe Temperature	•	•	•	•	•
Probe Inst. Number		•	•	•	•

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9/18/73

9/18/73 | 9/18/73 | 9/18/73 | 9/18/73

	TEST CROUP E	NP E				Test Number
Test Mucher	S	5	s	s		Date
Date	9/18/73 9/18/73 9/18/73 9/18/73	9/18/73	9/18/73	17/81/6	0/18/73	Skid Number
Stid Number	1	2	2	7		

	1003	Cooling Bay Pata	it.		
Cooling Bay - Position	3-1	3-2	2	3-4	1,2
Length of Shroud Time	7,	. 52	,	,	;
Cooling Bay Temp. Averages					
Α	79	79	2	79	20
æ	79	79	2	%	7.0
ပ	78	. 87	82	78	78
D	79	62	79	79	6,2
Bey	90	980	8	8	8

6:12

6:09

96:9

6:03

5:42

22

75

45

43

7

45

Duration of Pour Multipour Number Multipour Data (Second Pour)

Reservoir Temperature

Cup Temperature

Material Temporature

Duration of Pour Multipour Number

Time Powerd

17 8 2

173

177 178 178 178

174

177 177 178 178

177

Reservoir Temperature

Material Temperature

Oup Temperature

Shell Temperature

Time Poured

17, 27

Multipour Data (First Pour)

nits		- 09 - 09 -
Res	,	3
L-Ray Resul	1	
	Marcher of Sella Porman	

Number of Stells Foured	28	9	09	ş	ç
Humber of Criticals	0	٥	0	0	6
Mumber of Minors	0	0	0		0
Mumber of Cavities	°	0	0	0	°
Mumber of Good Shells	59	09	9	9	9
#Shell 37 omfered					

	Core	Core Melting Data	Data		
Time Start					
Time Probe Down		•	•		
Time Finish	٠			•	
Duration of Probe					
Probe Temperature			•		
Probe Unit Number	•	•	•		

							-	
			Test Mumber	9	9	9	. 6	Ą
			Date	/91/6	3 9/18/7	9/18/13 9/18/73 9/18/73 9/18/73	6/18//6	9/18/73
5	\$	\$:	:	:	:	:	;
			SKOLD MURDORT	11	77	13	14	2
	20,00,00							

Test Bomber	S	\$	3	5	\$
Date	9/18/73	9/18/73 9/18/73 9/18/73 9/18/73 9/18/73	9/18/73	9/18/73	9/18/73
Steld Number	9	7	60	6	10

TEST CHOUP E

	Cooli	Cooling Bay Data	it.		
Cooling Bay - Position	3-6	3-8	3-9	3-10	3-11
Length of Shroud Time	7.5	7.5	75	7.5	7.5
Cooling Ray Temp, Averages					
A.	79	79	62	62	96
	79	79	62	. 61	79
Ď	78	79	66	61	79
Q	61	81	18	18	19
¥	0	81	18	81	1

6:50

6:44

6:40

6:26

2

23

23

3

3

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8

Duration of Pour Multipour Number

Time Poured

Multipour Data (Second Pour)

Reservoir Temperature

Material Temperature

Cup Temperature

Multipour Mumber

Duration of Pour

Time Poured

175 178

175 178

175 177

175 173

> Material Temperature Shell Temperature

Multipour Data (First Pour)

22

172

Reservoir Temperature

Cup Temperature

	Ĭ	L-Ray Results			
Number of Shalls Poured	99	09	09	09	*65
Busher of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Mumber of Cavities	0	0	0	0	0

Member of Shalls Poured	9	09	90	09	*65
Busher of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Mumber of Cavities	0	0	0	0	0
Mumber of Good Shells	90	60	60	09	65
*Shell 55 omitted, low pour.					

		Core Meiting Date	Date		
Time Start	•	•	•	•	•
Time Probe Down	•	•	•	•	•
Time Finish	•	•	•	•	•
Duration of Probe	•	•	•	•	•
Probe Temperature	•			٠	•
Probe that Samber	•	•	•	•	•

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Test Mumber	9				
Date	6/18//3				
Skid Number	91	41	81	61	50

Multipour Data (First Pour)

9/18/73 9/18/73 9/18/73 9/18/73 9/18/73

TEST GROUP E

71

<u>...</u>

13

Sicia Number

Date

Cooling Bay Data
1 4-10 3

17-

Cooling Bay - Position Length of Shroud Time

Reservoir Temperature	172	173	173	172	172
Oup Temperature	177	178	178	183	. 178
Material Temperature	175	176	176	176	176
Shell Temperature	72	7.5	٤٤	23	6,7
Time Powed	6:34	7:03	7:06	7:12	7:16
Duration of Pour	41	37	39	77	77
Multipour Number	1	2	2	, 7	7

Multipour Data (Second Pour)

79

2 62

2

11

7,

m

Cooling Bay Temp. Averages

Reservoir Temperature	•	•	•		•	
Cup Temperature	•	•	•	•	•	
Material Temperature	•	•	•	•	•	
Time Poured	•	•	•			
Duration of Pour	•	•	•	•	•	
Multipour Number	•	•	•	•		

Core Melting Data

9

9

9

9

Number of Good Shells

Number of Minors Number of Cavities

Time Start	•	•	•	•	•
Time Probe Down	٠	•	•	٠	•
Time Finish	٠	•	•	•	•
Duration of Probe	,	•	•	٠	•
Probe Temperature	•	•	•	J	•
Probe Unit Number		•			

- 52		
?		
٠,		
•		Ray Results
`		X-Re
*		

9

Mumber of Shells Poured

Mumber of Criticals

152

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400
5
123

Test Mumber 6	9	9	9	9
Date 9/18/	9/18/73 9/18/73 9/18/73 9/18/73	9/18/73	9/18/73	9/18/73
Stid Number	17	18	19	20

Multipour Data (First Pour)

172

Reservoir Temperature

Cup Temperature

Material Temperature Shell Temperature

178

22

23

Skid Number

Dete

9/18/73

Test Mumber

Date	9/18/73	9/18/73 9/18/73 9/18/73 9/18/73 9/18/73	9/18/73	9/18/73	9/18/73
Std Nuber	16	11	18	19	30
	Cool	Cooling Bay 1-ta	t,		
Cooling Bay - Position	3-14	4-3	7-7	2-3	9-7
Length of Shroud Time					
Cooling Bay Teap. Averages					
*	84	2	92	92	92
B	62				
O	7.7				

Cooling Bay - Postaton					
	3-14	4-3	7-7	\$ - \$	9-7
Length of Shroad Time					
Cooling Bay Teap, Averages					
A 78	_	76	92	2	36
B 79	•	•	,		
C 5		;			
D 0	_				
Bey 79		7,9	79	79	79

3

Duration of Pour Multipour Number

Time Poured

7:21

	Z-Re	L-Ray Results			
Mumber of Shells Poured	99	09	09	09	9
Mumber of Criticals	0	0	°	0	0
Number of Minors	0	0	0	0	0
Mumber of Cavities	0	0	0	0	0
Number of Good Shells	09	09	99	09	9

	Multipo	ur Data (Multipour Data (Second Pour)	÷	
Reservoir Temperature	•	•			
Cup Temperature	•	•			
Material Temperature	•				
Time Poured					
Duration of Pour					!
Multipour Number	•				

	S	Core Melting Data	Data	
Time Start		L.		
Time Probe Down				
Time Finish	<u>'</u>	_		
Duration of Probe				
Probe Temperature				
Probe Unit Number				

TEST GROUP E

Test Number	6			
Date	9/18/73			
Skid Number	21 .	22		

Cooling Bay Data

Cooling Bay - Position		4-7		
Length of Shroud Time	75	75		
Cooling Bay Temp. Averages				
A	77	77	-	
В	- .	-		
C	-	-		
D	-	-		
Bay	79	79		

X-Ray Results

Number of Shells Poured	60	58A		
Number of Criticals	0	0		
Number of Minors	0	0		
Number of Cavities	0	0		-
Number of Good Shells	60	60		

A Shells 19 and 25 omitted from test, low pour.

GROUP F - CASTOR WAX

Test #	Explosive Temperature OF*	Shell Temperature F*
1	176	70
2	176	90
3	184	90
4	184	70

NOTES:

- Nominal temperature record actual temperature.
- 1. Use single pour.
- 2. Pour 4 skids per test.
- 3. Use wood shroud.
- 4. Cooling bay temperature was 90°F minimum.
- 5. Shroud time was 75 minutes, the total cooling time was
- 6. 3.75 hours minimum.
- 7. Use additional agitator in reservoir and maintain a minimum lower limit.
- 8. 100% X-ray all shells.
- 9. Section and color photograph two (2) shells from each test.

GROUP F DEFECT SUMMARY

Nominal Shell Temperature

70°	90°	
0	14M	2
1M	6С 63М	3

GROUP F

TEST 1

No defects were found.

TEST 2

There were 14 minor defects found. The last 3 skids of this test had a heavy wax build-up on top of the riser.

TEST 3

There were 6 critical and 63 minor defects found.

TEST 4

There was 1 minor defect found.

TEST 5

No defects were found.

TESTS 6 and 7

No test.

TEST 8

No defects were found.

TEST CROUP F

Test Number	1				
Date	12/61/6				
Skid Nurber	1	2	ŕ	7	

Multipour Data (First Pour)

- Reservoir Temperature	174	174	173	173	
Gup Tenperature	176	176	176	176	
Material Temperature	174	17.1	176	176	
Shell Temperature	20	7.5	69	7.1	
Time Poured	5.29	5 35	5 38	77 5	
Duration of Pour	4.5	\$7	65	45	
Multipour Number	٠,	٠,	2	, 3	

Multipour Data (Second Pour)

Reservoir Temperature	,	•	•	ı	
Cup Temperature	•	•		-	
Material Temperature	ŧ	•	•	•	
Time Poured		_	•	•	
Duration of Pour	ŧ		-	•	
Multipour Number		ı	ı	•	

Core Melting Data

Time Stant				
	•	•		
Time Probe Down	 •		_	
Time Finish	 -	ı		
Duration of Probe	 •	ı		
Probe Temperature			•	
Probe Unit Number -	•	•	•	

TEST GROUP F

Test Number	1				
Date	9/19/73				
Skid Number	1	2	3	7	

Cooling Bay Data

	_	_						
	3-4			93	16	93	8	66
	3-3			92	91	91	06	66
•	3-2	7.5		92	91	91	06	66
	3-1	75		26	91	92	06	66
	Cooling Bay - Position	Length of Shroud Time,	Cooling Bay Temp. Averages	γ	æ	υ	Q	‡ 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

X-Ray Results

Number of Shells Poured	594	_9B	9	90	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	1	0	
Number of Good Shells	59	59	09	09	

A. Shell #58 omitted, low pour. B. Shell #43 omitted, low pour.

Test Mader	2				
Date	61/61/6				
Steld Mumber	٩	9	,	8	

	мистро	munipour tent (first four)	rirst rol	۲,	
Beservoir Temperature	174	174	126	275	
Oup Temperature	176	\$21	175	275	
Material Temperature	176	7/1	174	52:	
Shell Tesperature	92-93	92-93 93-95	92	26	
Time Powed	5:49	5:55	\$:39	6:03	
Duration of Pour	95	55	57	25	
Multipour Number	2	2	2	2	

	mar capo	T THE PERSON AND ADDRESS OF THE PERSON ADDRESS OF THE PERSON AND ADDRESS OF THE PERSON AND ADDRESS OF THE PERSON A	mutipour pare (second rour)	m.'	
Beservoir Temperature	•	•	•	•	
Oup Temperature	•	•	•	•	
Material Temperahure	٠	•	•	•	
Time Foured	•	•	•	•	
Duration of Pour	•	•	•	•	
Multipour Masher	•	,	•	•	

Core Melting Data

Time Start	•		•	•	
Time Probe Down	•	•	•	•	
Time Pinish	•	•	•	•	
Duration of Probe	•	•	•	•	
Probe Temperature	•	•	•	•	
Probe Unit Musber	•	•	•	•	

TEST GROUP F

Test Mumber	2				
Date	6/161/6				
Skid Number	\$	9	7	8	

Cooling Ray Date

		,			
Cooling Bay - Position	3-5	3-6	3-8	11-7	
Length of Shroud Time					
Cooling Bay Temp. Averages					
γ .	93	93	93	06	
æ	16	26	26		
C	92	. 26	16	•	
Q	8	06	06.	•	
Bay	66	66	66	3	

L-Ray Results

Number of Shells Poured	60	90	60	60	
Number of Criticans	0	0	0	0	
Mumber of Hinora	10	0	1	3	
Mumber of Cavities	14	s	90	s	
Number of Good Shells	20	09	59	57	

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		2
3	1/61/5	•
Tost Number	Date	Skid Number

Mul' ipour Data (First Four)

Reservoir Temperature	188	180	192	\$£	
Cup Temperature	180	781	981	136	
Material Temperature	182	18;	187	187	
Shell Temperature	93	G	92	8	
Time Poured	9 77	6 50	\$ \$	7.0	
Duration of Pour	43	77	SS	0,7	
Multipour Number	. 2				

	Multipo	ur Data (Multipour Data (Second Pour)	Ę)	
Reservoir Temperature		•	•		
Cup Temperature	•	•			
Material Temperature		•	•		
Time Poured					
Duration of Pour					
Multipour Number					
	•		A-4-1-4-1-4-1-4-1-4-1-4-1-4-1-4-1-4-1-4-	ļ	

Core Melting Data

The Probe Down Time Finish Duration of Probe Probe Temperature		 	
Probe Unit Number			

TEST GROUP F

Test Number	3				
Date	8/15/73				
Skid Number	6	01	E	=	
	C001	Cooling Bay [-ta	4 3.		
Cooling Bay - Position	3-9	3-10	11-11	3-12	
Lergth of Shroud Time					
Cooling Bay Temp. Averages					
γ	91	16	91	16	

X-Ray Results

88

Bay

8 2 8

8

8 % 8

Number of Shells Poured	59A	99	89	8	
Number of Criticals	1	0	3	2	
Number of Minors	14	11	21	17	
Number of Cavities	23	14	28	22	
Number of Good Shells	77	6.7	35	15	

A. Shell #57 omitted, low pour B. Shell #19 omitted, low pour.

TEST CROUP F

THE CHOOS P

 Test Number	-4				
Date	9/19/73				
Skid Number	13	14	15	16	
	Coo11	Cooling Bey Data	it.		
Cooling Bay - Pouttion	4-10	3-12	3-13	3-14	
Length of Shroud Time					
Cooling Bay Temp. Averages					
٧	06	16	16	•	
e	•	16	16	•	
ဗ	•	88	88	•	
4	•	89	59		

187

187 186

982 :85 2

187 2

82

138 ž 186 2

198

3%

Becarvoir Temperature

Material Temperature Shell Texperature

Oup : Imperature

Multipour Data (First Pour)

*

2

Skild Number

Toot Ruber

7:24

7:19

7:15

7:10

2

39

33

67

2

Duretion of Pour Multipour Number

Time Poured

8

83

96

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)

3

3

0 0 0 Ş

Ş

A. Shell #52 omitted, low pour.

┖.	,					Come Maltine Date	2	
	0	0	Number of Cavities					
	٥	٥	Number of Minors		•			
	0	0	Mumber of Criticals	•	٠	•	•	
_	9	294	Number of Shells Poured	•	•	•	•	
	X-Ray Results	K-Ray		•	•	•	•	
		1		,	•			

Time Frobe Dom Time Finish Duration of Probe Probe Unit Number	Time Start	•	•	•	•	
Time Finish Duration of Probe Probe Temperature Probe Unit Number	Time Probe Dom	•	•			
Probe Unit Number	Time Finish	•	•	•		
Probe Unit Number	Duration of Probe	•	•	•	•	
Probe Unit Number	Probe Temperature	•	•	٠	•	
	Probe Unit Number	•	•	•	•	

A salah

Multipour Data (Second Pour)

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Her sevoir Temperature

Material Temperature

Ties Poured

Cap Temperature

Multipour Humber Duration of Pour

TEST CROUP TEST NUMBER TEST DATE

Skid Number

Multipour Date

183 178 92

182 178 180

182 178 8 2

182 178 180 2

Multipour Date

Skid Member

Reservoir Temperature

Material Temperature Shell Temperature

Cup Temperature

28 28 188 = 2

F 8 10/17/73

TEST CADUP TEST NUMBER TEST DATE

9:43

07:6

9:32

9

63

Duration of Pour Multipour Naber

Time Poured

Reservoir Temperature	178	178	1 78	9,	2
	-				9/1
Cup Temperature	177	177	178	128	66.1
					2
Material Temperature	175	175	176	176	176
Shell Temperature	0,	92	0,0	ž	۶
					?
Time Poured	9:0%	90:6	9.12	6.3	9.3
Duration of Pour	5	;			
	3	,	;	99	78
Multipour Number	~	,	,	,	,
		•	•	•	•

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	7.5	7.5	25	2	2
Average Cooling key Temp.	81	18	82	83	83

X-Ray Results

Number of Shells Poured	8	09	9	9	894
Number of Criticals	0	٥	۰	٥	٥
Mumber of Minors	0	٥	٥	٥	•
Number of Cavities	0	°	၀	O	٥
Mumber of Good Shells	ş	3	9	ş	53
Number of Shells with Porceity & crystallination	٥	c	0	o	•

A Shell I omitted from test, low pour.

Cooling Bay Date

Cooling Bay - Position	3-6	3-7	3-8	3-6	ě
Length of Shroud Time	75	7.5	7.5	25	2
Average Cooling Bay Temp.	83	83	82	82	2

X-My Meulte

Number of Shells Poured	09	09	09	09	ş
Number of Criticals	0	0	٥	°	٥
Number of Minore	0	0	٥	0	٥
Number of Cavities	0	0	0	٥	۰
Number of Good Shalls	%	99	09	9	3
Number of Shalls with Porosity & crystallisation	0	0	0	.0	•

GROUP G - SORTED HIGH VISCOSITY PETROLITE

Test #	Per Cent Scrap	Number of Skids
1	None	20
2	70%	10

TEST INSTRUCTIONS

- 1. Use shell temperature of 79 F max.
- 2. Reservoir agitation (w/additional agitator) and minimum lower level limit.
- 3. Use single pour, 178°F max.
- Use picatinny shroud.
- 5. Cooling bay temperature ambient and record.
- 6. Shroud time, 1 1/4 hrs minimum.
- 7. Total cooling time, 3 3/4 hrs minimum.
- 8. 100% X-ray all shells.

在大学中,这个人的一个人,我们就是一个人的一个人,我们不是一个人的,我们就是一个人的,我们就是一个人的,我们就是一个人的,我们就是一个人的,我们也会看到一个人的,他们

9. Section and color photograph two (2) shells from each test.

GROUP G - DEFECT SUMMARY

Test No.	Per Cent Scrap	<u>Defects</u>
1	0	0
2	70	0

TEST CHOUP C

	-				
That Mumber	1	1	1	1	,
Date	6/20/6				
Stdd Mumber	1	2	£	7	5

Multipour Data (First Pour)

Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	176
Material Temperature	175	175	177	175	174
Shell Temperature	7.5	51	73	7.5	2
Time Poured	5:38	5:42	5:45	5:50	5:53
Duration of Pour	53	\$\$	57	57	22
Multipour Busber	. 2	2	2	2 ,	~

fultipour Dota (Second Pour)

	wat cribo	ur Loue	mutipour rote (second rour)	E)	
Reservoir Temperature	•	•	•	•	•
Oup Temperature	•	•	•	•	•
Material Temperature	•	•			•
Time Poured	•	•			
Duration of Pour	•	•	•	•	•
Multipour Number	•	4	•	•	•

Core Melting Data

Time Start	•		•	•	
Time Probe Down				•	•
Time Pinish		•	•	•	•
Duration of Probe		•	•	•	
Probe Temperature		٠			
Probe Unit Number	-	ı	ı		

TEST CROUP G

Test Mumber	1				
Date	9/20/73				
Skdd Number	1	2	3	7	~

Cooling Bay Itta

	3-1	3-2	11-7	,	
Length of Chroud Time 75		.57	2,		*
Cooling Bay Temp. Averages	_				
A 82		82	ຣ	83	a
B		83		\$	2
23		. 2 5		28	2
79 Q		984		28	78
		87	28	6	3

X-Ray Results

Mumber of Shells Poured	09		8	\$	3	
Mumber of Criticals	0	0	0	٥		
Number of Minors	0	0		•	0	
Mumber of Cavities	0	0	۰	•		
Number of Good Shells	ક	8	Ş	ş	ş	

TEST CROUP G.

Test Number	1				
Date	9/20/73				
Skid Number	۵	,	8	6	10

Multipour Data (First Pour)

	1	1	Tar active many modern mu		
Reservoir Temperature	176	176	179	871	178
Cup Temperature	176	176	177	177	177
Material Temperature	17.5	175	176	176	175
Shell Temperature	13	7.2	0,	75	7.5
Time Poured	9 - 00	6 08	6:12	6 15	6 34
Duration of Pour	89	61	58	58	57
Multipour Number	2	3	2	2	;

Multipour Data (Second Pour)

Reservoir Temperature	•	•	,	•
Cup Temperature		•	•	•
Material Temperature		•	•	•
Time Poured .	•	•	•	•
Duration of Pow	•	٠	•	•
Multipour Number -	•	•		•

Core Melting Data

	•			•	
			6		-
•		•	•	•	•
•				•	
Time Start	Time Probe Down	Time Finish	Duration of Probe	Probe Temperature	Probe Unit Number

TEST GROUP G

Test Number	-				
Dete	9/20/73	3			
Skid Number	9	,	8	6	10

Cooling Bay Data

Cooling Bay . Position	3-5	3-6	3-8	3-9	3-10
Length of Shroud Time	7.5	75	7.5	75	75
Cooling Bay Temp. Averages					
A	83	83	84	84	83
æ	84	78	78	84	84
ပ	78	-78	84	84	78
Q	78	78	78	84	78
Bay	98	98	98	98	98

X-Ray Results

Number of Shells Poured	59A	60	09	9	9
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number or Cavities	0	0	0	0	c
Number of Good Shells	59	09	00	09	9

A Shell 21 omitted from test (X-rayed, OK).

¢	:	ŀ
2		
, +		
ŀ	٠	I

Test Number	1				
Dete	9/20/73				
Skid Number	11	12	13	14	15

Multipour Data (First Pcur)

			(mo : oo : :)	•	
Reservoir Temperature	178	178	178	178	178
Cup Temperature	177	221	221	177	1 5
Material Temperature	175	\$21	176	176	176
Shell Temperature	72	01	٤٤	7.6	23
Time Poured	05.9	77.9	6:47	6 · 50	6 53
Duration of Pour	-	55	25	53	75
Multipour Number	2	2	2	2	2

tiponr Data (Second Pour)

	נית ביותי	nara m	mor monac) page modrami	1	
Reservoir Temperature	•				
Cup Temperature		•			•
Material Temperature	•	•	•		
Time Poured	•	•			
Duration of Pour	•				
Multipour Number	•	•			

e Melting Data

Time Start Time Probe Down Time Finish Duration of Probe Probe Temperature Probe Unit Number		200	core metting usta	2227		
Time Probe Down Time Finish Duration of Probe Probe Temperature Probe Unit Number	Time Start	•	•			
Time Finish Duration of Probe Probe Temperature Probe Unit Number	Time Probe Down					
Probe Temperature Probe Unit Number	Time Finish				•	
Probe Temperature Probe Unit Number	Duration of Probe	•	•	•		
Probe Unit Number	Probe Temperature				•	
	Probe Unit Number	•			i (

TEST GROUP G

Test Number	1				
Date	9/20/73				
Skid Number	11	13	13	14	15

Cooling Bay Data

Cooling Bay - Festion	3-11	3-12	3-13	3-14	4-1
Length of Shroud Time	52	51	7.5	25	χ.
Cooling Bay Temp. Averages					
γ	83	83	83	83	8
В	84	84	78	78	'
ບ	83	83	83	83	٠
q	78	84	78	25	
Bay	86	86	88	8	88

X-Ray Results

Number of Shells Foured	9	99	36	3	ş
Number of Criticals	0	9	ر	U	3
Number of Minors	o	9	د	J	ی
Number of Cavities	U	3	6	c	9
Number of Good Shells	99	9	9	9	9

•	
•	

	9/20,7				-
Skid Number	4	`	×	2	2. -

	ישהי הכיני) פהשת שהמנה שני				
Reservoir Temporature	178	178	178	3.78	178
Gup Temperature	177	177	176	176	177
Material Temperature	175	175	177	176	1,76
Shell Temperature	7.5	7.7	78	75	22
Time Poured	6 57	75	7 :9	7.31	7 35
Duration of Pour	55	54	54	5.5	25
Multipour Number	۲۰.	٠,	6	2 '	2

	Reservoir Temperature Cup Temperature Material Temperature Time Poured Duration of Pour

Core Melting Data

Time Start	•				
Time Probe Down			•	•	•
Time Finish			•	•	
Duration of Frobe	•	•	•	Đ	o
Probe Temperature	•	•		•	•
Probe Unit Number		•		•	

7E57 . Au. : 1

Test Number				
10000				
Date 9/20/73	١,			
Skid Number	17	18	19	20

Cooling Bay Data

Cooling Bay - Festion 4-2 4-3 4-17 4-13 4-14 </th <th></th> <th></th> <th></th> <th></th> <th>1</th> <th></th>					1	
83	Cooling Bay - Festtion	4-2	£-7	21-7	i	
83	Length of Shroud Time	7.5	25	52	2,2	75
85 85 85 85	Cooling Bay Temp. Averages					
	٧	83	,	63	83	83
	В					
	ບ		•	,		
85 85 85 85	g	ı	•	•		
	Вау	85	88	88	88	€

X-Ray Results

Number of Shells Poured	36	66	64	79	64,
Number of Criticals	0		7	7	0
Number of Manors	ני	3	Ŋ	ی	3
Mumber of Cavities	Ü	0	0	0	3
Number of Good Shells	99	9	09	09	9

G 2 9/21/73 TEST CROUP TEST NUMBER TEST DATE

Skid Number

2:41 2 · 28 2:35 2:26 의 Multipour Date Reservoir Temperature Material Temperature Shell Temperature Multipour Number Duration of Pour Cup Temperature Time Poured

Cooling Bay Data

5-5 5-3 5-2 5. Average Cooling Bey Temp. Cooling Bay - Position Length of Shroud Time

X-Ray Results

S Mumber of Shells with Porceity & crystallization Number of Shells Poured tumber of Good Shells Number of Criticals Mumber of Cavities Number of Minors

TEST CROUP TEST NUMBER TEST DATE

Skid Number

Multipour Data ire Reservoir Tempe.

3:36 = 3:28 7, \simeq 3:18 Material Temperature Shell Temperature Multipour Number Duration of Pour Cup Temperature Time Poured

Cooling Bay Date

5-10 5-8 2-7 2-6 Average Cooling Bay Temp. Cooling Bay - Position Length of Shroud Time

X-Ray Results

ç o c Number of Shells with Porosity & crystallization Number of Shells Foured Number of Good Shells Number of Criticals Number of Cavities Number of Minors

GROUP H - BAD LOT PETROLITE

Test No.	Percent Scrap	<u>Defects</u>
1	0	0
2	40	0

NOTES:

- 1. Shell temperature 75° to 79°F.
- 2. Material temperature 174 to $178^{\circ}F$.
- 3. Single pour.
- 4. 20 skids per test.
- 5. Use Picatinny shroud.
- 6. Record cooling bay temperature.
- 7. Shroud time 1.25 hours.
- 8. Total cooling time 3.75 hours.
- 9. 100% X-ray all shells.
- 10. Reservoir agitation (with additional agitator) and maintain a minimum lower limit.
- 11. Use unsorted "Bad Lot" Petrolite Lot HOL 053-5095 or HOL 053-5096.

·=	l 9/24/73
TEST CADUP	TEST NUMBER TEST DATE

TEST CROUP TEST NUMBER TEST DATE

Skid Number	_	,	3	7	S	Skid Number
Multipour Data	ata					
Reservoir Temperature	175	174	176	1,7,	180	d
Cup Temperature	178	177	177	180	180	Cin Temporature
						10000 11 11 11 11 11 11 11 11 11 11 11 1

Reservoir Temperature	175	174	176	177	180
Cup Temperature	178	177	177	180	180
Material Temperature	721	17.2	173	175	174
Shell Temperature	78	77	8	2	2
Time Poured	6:58	7.04	7.10	7.15	7:18
Duration of Pour	87	57	58	58	2
Multipour Number	٠,	2	2	۲.	2

7:42

7:34

7:28

7:23

22

25

20

67

24

Duration of Pour Multipour Number

Time Poured

7,

23

82

23

174

174

Material Tenperature Shell Temperature

178

181

280 180 174

180

180

Multipour Dyta

3-10

3-8

7

9-6

Cooling Bay - Position

Cooling Bay Data

2 83

25 83

75 83

75 83

83 7.5

Average Cooling Bay Temp.

Length of Shroud Time

X-Ray Results

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Tire	7.5	7.5	75	7.5	75
Average Cooling Bay Temp.	83	83	83	83	83

Cooling Bay - Position	3-1	3-2	3-3 3-4	3-4	3-5	
Length of Shroud Tire	7.5	7.5	75	3	75	
Average Cooling Bay Temp.	83	83	83	83	83	
X - Ray	X-Ray Results					
Number of Shells Poured	09	09	90	94	194	
			3	3	8	
Number of Criticals	c	0	•	_	_	
				,		

Number of Shells Poured	89A	09	99	09	09
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	ç,	0
Number of Cavities	0	0	0	0	٥
Number of Good Shells	59	09	50	09	09
Number of Shells with Porosity & crystallization		. 0	0	0	°

09 c

9

9 0

9 0

9

Number of Good Shells

Number of Cavities Number of Minors

Number of Shells with Porosity & crystallization

c 0 ٥

Cooling Bay Data

A Shell 55 omitted, low pour (X-rayed - no defect).

TEST CHOUP TEST NUMBER THET DATE

51 71 11 11 11

Multipour Data	Data				
Meservoir Temperature	181	182	182	181	180
Cup Temperature	180	180	180	180	178
Material Temperature	176	176	176	176	176
Shell Temperature	76	92	27	77	77
Time Poured	7:47	7:51	7.54	7.56	7:59
Duration of Pour	35	51	•	80	52
Multipour Number	2	2	2	2	2

9/24/73 TEST CROUP TEST NUMBER TEST DATE

100 Carlos

• 1

Skid Number	16	17	18	19	20
Multipour Data	Data				
	999		9,	081	180

Reservoir Temperature	180	181	180	180	180
Cup Temperature	179	180	180	180	179
Material Temperature	176	178	176	177	177
Shell Temperature	77	77	22	7.7	11
Time Poured	8:03	8 05	918	81:8	9 20
Duration of Pour	87	67	57	\$7	•
Hultipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	2-7	4-3	7-7	4-5	4-5
Length of Shroud Time	75	75	7.5	7.5	51
Average Cooling Bay Temp.	85	85	85	85	85

3-13

Cooling Bay Data

X-Ray Results

89

9

9

9

3

Number of Shells Poured

Number of Criticals

X-Ray Results

Average Cooling Bay Temp.

\$ 0

8

9

9

8

Number of Good Shells

Number of Cavities Number of Minors

ح 0

0 0

0 0

0

Number of Shells Poured	60	60	59A	898	9
Number of Criticals	0	C	ι	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	3	3	1	9	0
Number of Good Shells	79	79	58	65	09
Number of Shells with Porosity & crystallization	•	0	0	n	•

Shell 55 omitted, low pour (X-rayed - critical defect). Mumber of Shells with Porosity 6 crystallization

Shell 11 omitted, low pour (X-rayed, critical defect). Shell 55 omitted, low pour (X-rayed, critical defect).

では、これでは、これでは、「日本のでは、「

Cooling Bay - Position

Length of Shroud Time

н ; 9, . 5, 73 TEST CROUP TEST NUMBER TEST DATE

Skid Number

Multipour Data

Reservoir Temperature	571	7.7	17.	17.	174
Cup Temperature	178	177	176	17.1	176
Material Temperature	176	176	176	175	176
Shell Temperature	7.7	77	77	77	78
Time Poured	5:38	5 41	5:45	87 5	3.56
Duration of Pour	80	50	7%	67	80
Multipour Number	,	,	,	,	

3-5 7.5 3

3-4 75 3

-5 3

3-2 75 3

7

Cooling Bay - Position Length of Shroud Time

2 9

Average Cooling Bay Temp.

Cooling Bay Data

6:41

6:17

6:12

6:07

90:9

92

7.

26

2

65

67

2 61

Duration of Pour Multipour Number

Time Poured

176 176

174 176 176 27

7.

174 177 176 29

174 = 176

Reservoir Temperature

Meterial Temperaturi Shell Temperature

Cup Temperature

Multipour Data

Skid Number

н 2 9/25,73

TEST GROUP TEST NUMBER TEST DATE

175 92

177 17

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	7.5	7.5	25	75	2
Average Cooling Bay Terp.	16	16	16	91	8

Cooling Bay Data

X-Ray Results

Number of Shells Poured	60	9	89A	09	99
Number of Criticals	0	0	٥	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	٥	0	o
Number of Good Shells	9	09	65	09	99
Number of Shells with Porosity 6 crystallization	0	. 0	0	0	٥

Shell 36 omitted, low pour.

X-Ray Results

Number of Shells Poured	09	88	09	29B	290
Number of Criticals	٥	0	٥	0	
Number of Minors	0	0	٥	0	
Number of Cavities	0	0		0	
Number of Good Shells	09	59	9	59	88
Number of Shells with Porosity & crystallization	0	0	0	0	0

Shell 42 omitted from test. Shell 42 omitted from test. Shell 15 omitted from test, low pour.

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и 2 9/25/73

TEST CROUP TEST NUMBER TEST DATE

TEST CNOUP TEST NUMBER JEST DATE

Skid Number	11	1.	13	14	15
Multipour Date	Date				
Reservoir Temperature	921	176	174	174	174
Cup Temperature	176	176	176	175	176
P. erial Temporature	175	175	175	176	175
Shell Temperature	"	3.6	76	7.5	76
Time Pourid	85.9	6:57	7:04	7.07	7:14
Duractun of Pour	\$\$	34	57	58	59
Multipour Number	2	2	2	2	ę,

Cooling Bay Data

Cooling Bay - Position	11:	3-12	3-13	3-14	17
Length of Shroud Time	13	75	23	75	75
Average Cooling Bay Temp.	더	92	88	36	88

Number of Shelis Poured	٧6,	9	90	60	69
Number of Criticals	0	0	0	0	0
Number of h. ors	0	С	,	0	0
Number of avities	0	0	0	0	0
Aumber of Goo; Shells	89	09	ĵ	09	09
Mamber of Shells with Porosity 6 crystallization	0	c	0	0	0

A Shell 57 cmitted, low pour.

Cooling Bay Data

7.56

7:45

1 42

. 3.

7.39

92

83

7.7

\$

25

Duretion of Pour Multipour Number

Time Poured

176 176 179 23

176 176

> 177 177

2 176 2

176

174 2 176 7,

Reservoir Temperature

Material Temperature Shell Temperature

Cup Temperature

Multipour Data

180

Cooling Bay - Position	7-5	4-3	4-4	4 .5	9-7
Length of Shroud Time	22	7.5	7.5	7.5	7.5
Average Cooling Bay Temp.	88	88	88	88	88

-Ray Results

Number of Shells Poured	09	09	09	60	57A
Number of Criticals	0	3	0	0	•
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	જ	09	09	09	25
Number of Shells with Porosity 6 crystallizet. 34	0	0	0	0	0

6 Shells 58, 59, and 60 omitter, shells "hot,"

TEST CROPT TEST NIMBER TEST DATE

·		
	^	
	ļ	
	^	
-		
-	7	
1		
!	_	
	Skid Number	

Reservoir Temperature	::	82	17.7		2
tup Temperature	177	177	12.	176	176
Material Je. e. dure	178	221	-2	176	1.2
Shell Terperature	۲,	1.	×	1,7	7.7
Tine Eured	۶ ۵۰۰	., 4	£,	\$ 5.3	\$ 26
Duration of Pour	"	4.4	5	;	20
Multipour Number	٠,	٠.	٠.	^.	٠.

Skid Sumber

н 3 10/16/73

TEST CROUF TEST NUMBER TEST DATE

Reservoir Temperature	176	176	176	176	176
Cup Temperature	921	176	176	₩1	176
Material Temperature	176	1.76	176	176	1,8
Shell Ter erature	72	22	21	7,	7.
11mo Penred	5 59	\$0.9	01 9	71.9	6.39
Duration of Loui	47	75	55	53	22
Hultipour Number	٠٠	2	2	2	2

Cooling Bay Data

 3-2 1-3 1-4 1-5	75 . 75 75	84 83
 Cooling have Peritting 3-	length of Shroud 11-e 75	Average Couling Bay Temp. 83

X-Ray Results

Number of Shell Toured	90	94	9	99	Ę
Number of Criticals	0	c	=	c	5
Surber of Whier-	c	5	=	5	6
Aumber of Cavities	٤	2	0	-	o
Sur'er of cood Shells	90	99	9	99	93
Number of Shells with Porosity & crystallization	e	c	0	c	0

Couling Bay Data

78

83

Average Cooling hav Jemp.

Cooling Say - Position Length of Shroud Tire

X+bny	X-My Results				
Number of Shells, I sured	60	60	99	09	09
Number of Criticals	Ü	U	0	0	c
Number of Amors	ú	ں	13	С	j
Number of Cavities	o	0	·	0	o
Number of Cood Shells	60	09	09	09	09
Number of Shells with Porosity & crystallization	c	o.	0	O	0

TEST GROUP	TEST NUMBER	PEST DATE
=		10/16/73
TEST GROUP	TEST NUMBER	TEST DATE

. н 3 10/16/73

-1

Skid Number	=	2	Ξ	14	_	Skid Number
Multipo	Multipour Data (First Four)	st Pour)				
Reserveir Temperature	174	176	176	9/.1	176	Reservoir Tensoratu
Cap Tenperature	174	177	9/1	176	921	Cup Temperature
Material Temperature	175	175	176	176	176	Haterial Temperatur
Shell Temperature	1,1	2.2	13	7/	72	Shell Temperature
Time Poured	6:42	57.9	27:9	6:55	5.58	Time Poured
Duration of Pour	53	53	25	15	51	Duration of Pour
Multipour Number	2	2	2	2	2	Multipour Number

S

67

87

2

7:02

176

176

r Tenperature

176 2

Temperature

Hultipour Data (First Pour)

2-13

2-12

2-11

Cooling Bay - Fusition

Length of Shroud Time

Average Cooling Bay Temp.

Cooling Bay .ata

Cool fu	Cooling Bay Data				
Cooling bay - Position	3-11	3-12	3-12 3-13	3-14	7-10
Length of Shroud Time	52	25	7.5	7.5	75
Accessed C. Man Box John	82	82	92	82	81

		L			
Number of Shells Pouted	99	9	9	9	9
Number of Criticals	0	U	9	0	0
Number of Minors	υ	0	0	0	0
Number of Cavities	0	o	O	0	0
Number of Good Shells	60	05	09	60	09
Number of Shells with Poresity & crystallization	0	0	0	0	0

X-Ray	X-Ray Results				
Number of Shells Poured	09	9	9	09	
Number of Critical	0	0	0		
Number of Minors	9	•	٥	۰	
Number of Cavities	0	0	0	0	
Number of Good Shells	09	69	09	38	
Number of Shells with Porosity 6 crystallization	0	0	င	0	

GROUP I

TEST 1

There were 2 minor defects found.

TEST 2

No defects were found.

Wax was observed on top of the riser for the first 5 skids in this test.

TEST 3

There were 2 minor defects found. Skids 1 and 2 had an unusually high number of low pours due to problems with the multipour. The water temperature around the cups was increased before pouring skid 3 to alleviate the problems with the multipour. Wax was observed on top of 8 of the 21 skids poured.

TEST 4

There were 3 critical and 14 minor defects found. Wax was observed on top of 4 of the 10 skids in the test.

TEST 5

There were 2 critical and 10 minor defects found. It should be pointed out that the 2 skids with a steel temperature of $74^{\circ}F$. did not have any defects while the other 5 skids (with a steel temperature of $75^{\circ}F$.) did. This relationship does not hold true for Test 4.

1/97/0 TEST CNOUP TEST NUMBER TEST DATE

TEST GROUP TEST NUMBER TEST DATE Skio Number Skid Number

Multipour Date

71 9

6 11

90 9

6 03

5:57

53

 \mathbb{S}

53

24

7

Duration of Pour Multipour Number

78

80

8

42

174

174

<u>.</u>2

174 2

Reservoir Temperature

Multipour Date

1,76 176 9,

2

176 175

176 175

176 176

177

Material Temperature

Cup Temperature

Shell Temperature

Time Poured

3-10

3-9

3-8

3-7

3-6

Cooling Bay - Position

Length of Shroud Time

Cooling Bay Data

2 93

2

2

22 93

75 93

93

Average Cooling Bay Temp.

X-Ray Results

Cooling Bay Date

3-5 2 2 3-4 22 8 3-3 2 3 3-2 2 35 ₹ S 6 Average Cooling Bay Temp. Cooling Bay - Position Length of Sirroud Time

X-Ray Results

9 ŝ 0 c **-**0 9 9 0 5 c 9 8 o Þ 3 9 o ٥ > 0 ŝ ş 0 0 0 Number of Shells with Porosity 6 crystallization Number of Shells Poured Number of Good Shells Number of Criticals Number of Cavitles Mumber of Minors

TEST CROUP TEST NUMBER TEST DATE

2 9/26/73

Skid Number

Multipour Data	Data				
Reservoir Temperature	174	174	174	27.1	176
Cuu Temperature	175	175	176	176	176
Material Temperature	174	174	176	176	176
Shell Temperature	77	79	18	11	67
Time Poured	6.33	7 60	7 06	- 1	7.15
Duration of Pour	\$9	59	34	53	43
Hultipour Number	2	۲,	۲،	٠.	2

178

2

29

62

6

61 /

7 30

2

73

Duration of Pour Multipour Number

Time Poured

20

16

82

1

2

Skid Number

TEST GROUP TEST NUMBER TEST DATE

178 1,76

Reservoir Temperature

Cup Temperature

Material Temperature Shell Temperature

Multipour Date

176 176

Cooling Bay Data

Cooling Bay - Position	3-11	J-12	3-13	3-14	;
Length of Shroud Time	70	7.5	75	75	75
Average Cooling Bay Temp.	91	93	43	93	8

X-Ray Results

Number of Shells Poured	60	90	58A	5.7H	9
Number of Criticals	0	0	0	٥	J
Musber of Minor.	0	0	G	٥	c
Humber of Cavities	0	ŋ	0	0	0
Number of Good Shells	09	09	88	25	09
Number of Shells with Foresity & crystallization	0	0	ŋ	0	Q.

Shells 10 and 35 omitted, low pours. Shells 5, 34, and 35 omitted, low pours.

Cooling Bay Data

Cooling Bay - Position	4-3	7-3	7-7	4-5	9-7
Length of Shroud Time	7.5	7,	75	25	7.5
Average Cooling Bay Temp.	06	06	06	8	05

X-Ray Results

Number of Shells Poured	59A	58h	99	99	99
Number of Criticals	0	ð	ก	0	0
Number of Minors	0	O	o	Ŋ	С
Number of Cavities	0	0	0	0	υ
Number of Good Shells	\$9	58	09	90	09
Number of Shells with Porosity 6 crystallization	ن	0	Û	ຄ	0

A Shell 5 omitted, low pour, R Shells 40 and 41 omitted.

i 3 9/27/73 TEST CHOUR TEST NUMBER TEST DATE

Skid Number	1	2	3	7	\$
Multipour Dats	Data				
Reservoir Temperature	172	172	174	176	172
Cup Temperature	175	185	184	190	180
Material Temperatur:	175	17.6	175	175	176
Shell Temperature	7,5	76	41	76	7.3
Time Poured	209 755	50.9	4., 4	6 11	6 14
Duration of Pour	75	96	35	4.5	56

3 9/27/73 TEST CHOUP TEST NUMBER TEST DATE

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Multipour Data

Reservoir Temperature	174	173	174	174	173
Cup Temporature	186	184	184	176	179
Material Terporature	175	178	178	180	179
Shell Temperature	78	٩	12	7.5	75
Time Poured	6 17 6.21	6.21	6.25	6.28	6.31
Duration of Pour	09	77	57	57	73
Hultinour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	1-7 71-8	4-1	2-7	4-3	7-7
Length of Shroud Time	75	75	52	75	7.5
verage Cooling Bay Temp.	35	16	16	16	16

3-13 7

3-1-

11-1 Υ.

3-10

Cooling Bay Data

Multipour Yumber

3.

3

Average Cooling, Bav Temp. Length of Shroud Time

X-Ray Results

Number of Shells Poured	69	09	60	60	9
Number of Criticals	0	0	0	0	0
Number of Minors	٥	S	0	ı	0
Number of Cavitles	٥	0	ı	1	0
Number of Good Shells	Ç	04	09	39	09
Number of Shells with Porosity & crystallization	٥	0	0	0	0

X-Ray Results

Number of Shells Poured	V07	<5R	6-0	60	9
Number of Criticals	٥	O	0	0	0
Number of Minors	0	٩	1	0	0
Number of Cavities	c	c		1	0
Surber of Good Shells	0.7	5.5	65	09	09
Number of Shells with Porosity & crystallization	٥	0	0	0	0

shills 1, 4, 5, 7, 8, 10, 13, 15, 56, 59, 60 emitted, lew pour. Shills 1, 5, 13, 56, 59 emitted, lew pour. ~ ×

TEST CROUP 1
TEST NUMBER 3
TEST DATE 9/27/73

Skii Number

Multipour Date

Reservoir Temperature	171 172	172	173	741	173
Cup Temperature	178	182	181	981	186
Material Temperature	175	176	176	176	179
Shell Temperature	•	11	7.5	75	25
Time Poured	21 6	7 12 7 16	07 2	7.25	7 29
Duration of Pour	ደ	\$\$	67	97	57
Multipour Number	•	2	5	7	~1
				1000	

Cooling Bay Data

Cooling Bay - Position	4-5	9-7	4-7	6-7	4-10
Length of Shroud Time	52	7.5	7.5	7.	25
Average Cooling Bay Temp.	16	91	91	16	<u> </u>

X-Ray Results

Number of Shells Poured	9	60	99	09	58A
Number of Criticals	0	0	0	0	0
Number of Minors	٠ ا	0	0	0	0
Number of Cazities	С	0	0	0	o
Number of Good Shells	99	09	60	09	85
Number of Shells with Porosity 6 crystallization	0	0	1	0	0

1 3 9/27/73 TEST CROP? TEST NYABER TEST DATE

19	20
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Reservoir Temperature	174	174	174	241	171
Cur Temperature	186	178	178	921	921
Material Temperature	179	179	179	178	180
Shell Temperature	72	7.4	74	74	7.2
Time Poured	7 32	7 32 7 36	07 2	97 2	15 2
Duration of Pour	57	17	27	07	38
Multipour Number	٠,	5	2	2	٠,

Cooling Bay Data

Cooling 3ay - Position	4-11 4-12	4-12	4-13	4-13 4-13	4-14
Length of Shroud Time	7.5	7.5	75	25	\$2
Average Cooling Bay Temp.	91	lo	10	16	16

X-Ray Results

Number of Shells Poured	90	99	09	55A	52B
Number of Criticals	0	0	0	0	0
Number of Minors	0	O	0	0	0
Number of Cavities	0	0	υ	0	0
Number of Good Shells	99	60	09	\$\$	25
Number of Shells with Porosity & crystallization	0	0	0	0	0

Shells 2, 3, 46, 57, and 58 omitted. Shells 1, 2, 3, 38, 49, 55, 56, and 57 omitted.

TEST CROUP : TEST NUMBER TEST DATE 9/.8/?)	5 ,	Multipour Data	stature 175 175 175 173	2 180 180 176 177	rature 176 175 176 176 177	ure 74 74 15 75 75	1 58 . 62 2 65 2 07 2 27	nr - 53 55 54 54	2 2 2 2 2
	Skid Number		Recervoir Temperature	Cup Temperature	Material Temperature	Shell Temperature	Time Poured	Duration of Pour	Hultipour Number
TEST GROUP 1 TEST NUMBER 1 TEST DATE 9 3	1.	Multipour Data	17.2	9.1		77	7.56)(2
	Skid Number	Mul	Reservoir Temperature	Jue lenperature	Haterial Temperature	Shell Tenperature	Time Poured	Duration of Pour	Multipour Number

		_							
7-5	25	87		09	0	7	S	58	
7-4	7.5	86		09	_	2		57	0
7-3	25	86		09	0	2	۲,	8,	0
7-2	75	86		n9	0	0	0	09	0
7-1	7.5	86	X-Ray Results	7)9	5	2	7	56	0
Cooling Bay - Position	Length of Shroud Time	Average Cooling Bay Temp.	X-Ray	Number of Shells Poured	Number of Criticals	Number of Minors	Number of Cavities	Number of Good Shells	Number of Shells with Porcity 6 crystallization
3-8	75	.6	X-Ray Results	99	0	0	c	09	c
		Average Cooling Bay, Temp.	X-Ray	Number of Shells Foured			Number of Cavities	Number of Good Shells	Number of Shelis with Porosity & crystallization

Cooling Bay Data

Cooling Bay Data

_	7	
CROUP	NUMBER	
E	TEST	

9/28/73 TEST DATE Skid Number

Multipour Data

מוריוחמין הפופ	מפרפ				
Reservoir Temperature	173	174	175	175	175
Cup Temperature	177	175	175	175	175
Material Temperature	176	176	175	175	175
Shell Temperature	7.5	7.5	7.5	7.5	7.5
Time Poured	2:30 2:34	2:34	2:37	2:39	2.43
Duration of Pour	55	•	95	95	75
Multipour Number	2	2	2	2	:

Cooling Bay Data

pp. 87 75 75 75	Cooling Rev - Posteton	3-6	7.7	8-6	9-6	01-6
Length of Shroud Time 75 75 75 75 75 75 Avarage Cooling Bay Temp. 87 87 87			,,,,			
Average Cooling Bay Temp. 87 87	Length of Shroud Time	7.5	75	75	75	7.5
	Average Cooling Bay Temp.	87				87

X-Ray Results

Mumber of Shells Poured	60	90	99	09	09
Mumber of Criticals	0	0	0	0	0
Aumber of Minors	2	1	1	0	O
Number of Cavities	3	1	3	0	0
Number of Good Shells	58	65	59	9	09
Mumber of Shells with Porosity 6 crystallization	0	. 0	0	0	0

1 5 9/28/73 Test group Test number Test date

Skid Number	11	21	1.1	71	15
Multipour Date	956				
Reservoir Temperature	185	184	184	184	184
Cun Temperature	175	175	175	175	175
Material Temperature	177	176	176	177	177
Shell Temperature	75	71	52	52	\$2
Time Poured	2:53	2.56	3.00	3 06	3:11
Duration of Pour	5.1	25	52	27	٤٦
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	7-11	7-12	7-13	7-14	3-10
Length of Shroud Iime	75	75	75	7.5	7.5
Average Cooling Bay Temp.	88	88	88	88	76

Number of Shells Poured	99	60	9	60	60
Number of Criticals	0	0	0	2	0
Number of Minors	2	0	7	1	2
Number of Cavities	2	0	7	7	2
Number of Good Shells	58	09	95	55	58
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST GROUP TEST NUMBER

9/28/73 TEST DATE

Skid Number	16	17		

Multipour Data

Reservoir Temperature	185	185		
Cup Temperature	175	175		
Material Temperature	177	176		
Shell Temperature	75	74		
Time Poured	3:14	3:18		
Duration of Pour	46	52		
Multipour Number	2	2		

Cooling Bay Data

Cooling Bay - Position	3-11	3-12		
Length of Shroud Time	75	75		
Average Cooling Bay Temp.	94	94		

Number of Shells Poured	60	60		
Number of Criticals	0	0		
Number of Minors	1	0		
Number of Cavities	1	0		
Number of Good Shells	59	60		
Number of Shells with Porosity & crystallization	0	O		

GROUP J INDRAMIC

Test No.	Number of Skids	Percent Scrap	Shell Temperature	Material Temperature	Probe Depth	Probe Time
1	4	0	70	176	-	-
2	4	0	90	176	-	-
3	4	0	90	184	-	-
4	4	0	70	184	••	-
5	4	40	80-85	180-184	3.5	2.5
6	4	40	80-85	180-184	3.5	15 seconds
7	4	40	80-85	180-184	1.5	2.5
8	4	40	80-85	180-184	1.5	15 seconds
9	4	40	80-85	180 - 1.84	-	-
10	10	40	75-79	173-179	-	-
11	4	40	90	173-179	3.5	2.5
12	4	40	90	173-179	3.5	5
13	2	40	90	173-179	-	-
14	10	0	75-79	173-179	-	-
1.5	10	70	75-79	173-179	-	-
16	15	40	75 - 79	173-179	-	-
17	5	40	75-79	180	-	-
18	5	40	80-85	180	-	-
19	خَ	40	75-79	184	-	-
20	5	40	80-85	184	-	-

NOTES:

- Use additional agitator in reservoir and maintain a minimum lower limit.
- 2. Single pour all skids.
- 3. Picatinny shroud was used.
- 4. Shroud time was 75 minutes.
- 5. The total cooling time was 3.75 hours.
- 6. Temperatures are nominal, the actual temperature was recorded.
- 7. All shells were 100% X-rayed.
- 8. Cooling bay temperature was ambient and recorded except for Tests 1 thru 4, for which a minimum temperature of 90 F was maintained.
- 9. Probe depths are measured from the breakoff point in the riser.

GROUP J

TEST 1

No defects were found.

TEST 2

There were 39 critical and 15 minor defects found. Wax was observed on top of the risers on skids 5 and 8.

TEST 3

There were 126 critical and 86 minor defects found. All of the risers were covered with wax. The wax covered 20 to 60% of the surface of the explosive in the riser. Prior to pouring the skids in this test, a layer of liquid material was observed floating on top of the explosive in Kettle 1. A sample of this material was removed and it was determined that the material was predominantly wax.

TEST 4

There were 6 critical defects found. Approximately 50 to 70% of the explosive surface in the risers were covered with wax. All of the defects occurred on the last two skids poured for the day.

TEST 5

There was 1 critical and 2 minor defects found.

TEST 6

There were 3 critical and 4 minor defects found.

There were 19 critical and 17 minor defects found. Wax covering 15 to 20% of the explosive surface in the risers was observed on all of the skids.

TEST 8

There were 12 critical and 34 minor defects found. The last three skids in the days test were poured using virgin material. This was necessary due to the lack of scrap. Wax covering 50 to 60% of the explosive surface was noted on the last three skids. It should be noted that the first skid in the test, poured with 40% scrap, had the lowest percentage of defects of any skid in this test.

TEST 9

There were 7 minor defects found. Skid 1 was to be probed but it would not tit under the probe machine. The shroud was removed when the attempt was made to place the skid under the probe machine. This skid had 5 minor defects.

TEST 10

Me detects were found.

TEST 11

There were 3 critical and 30 minor defects found.

TEST 12

There were 'critical and 18 minor defects found. Mechanical problems were encountered in the multipour unit resulting in low pours in row 6 through 60 on several skids poured prior to skid 18.

There were 19 critical and 17 minor defects found. Wax covering 15 to 20% of the explosive surface in ths risers was observed on all of the skids.

TEST 8

There were 12 critical and 34 minor defects found. The last three skids in the days test were poured using virgin material. This was necessary due to the lack of scrap. Wax covering 50 to 60% of the explosive surface was noted on the last three skids. It should be noted that the first skid in the test, poured with 40% scrap, had the lowest percentage of defects of any skid in this test.

TEST 9

There were 7 minc: defects found. Skid 1 was to be probed but it would not fit under the probe machine. The shroud was removed when the attempt was made to place the skid under the probe machine. This skid had 5 minor defects.

TEST 10

No defects were found.

TEST 11

There were 3 critical and 30 minor defects found.

TEST 12

There were a critical and 18 minor defects found. Mechanical problems were encountered in the multipour unit resulting in low pours in row 6 through 60 on several skids poured prior to skid 18.

There were 5 critical and 26 minor defects found on the 2 skids in this test.

TEST 14

No defects were found.

TEST 15

No defects were found. Skids 19 and 20 (last two skids in the test) contained less than 70% scrap due to a lack of scrap material.

TEST 16

No defects were found.

TEST 17

No defects were found.

TEST 18

One minor defect was found.

TEST 19

There were 2 critical and 2 minor defects found. All of the defects occurred on skid 15 which had the highest steel temperature (78°F.). This skid was placed in cooling bay 3 rather than cooling bay 4 as were the rest of the skids in this test. It should be pointed out that the temperatures were in the load to middle 80's in both cooling bays.

There were 11 critical and 16 minor defects found.

TEST 21

No defects were found.

, , 10/1/71 TEST GROUP TEST KINGER TEST DATE

J. 2 10/1/73

TEST CROUP TEST NUMBER TEST PATE

Skid Number

Pred indivini					
Reservoir Temperature	χ.	<u>-</u>	177	178	
Cup Temperature	175	ę.	411	17.	
Material Temperatur:	175	176	176	175	
Shell Temperature	7.2	11	~	72	
Time Poured	5.30	3.40	5.45	67 5	
Duration of Pour	150	z	Š	55	
Multipour Number	~	~.	2	~	

178 176 93

180 176

> 175 6

Material Temperature Shell Temperature

178 179 176 6

176

Reservoir Temperature

Cup Temperature

Multipour Date

Skid Number

8

79

3

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99

Multipour Number Duration of Pour

6:12

Time Poured

Cooling Bay Data

Cooling Bay - Position	1-1	3-2	3-3	7-1	
Length of Saroud Time	100	06	85	18	
Average Cooling Bay Temp.	93	93	93	36	

X-Ray Results

Number of Shells Poured	\$28	ş	09	80	
Number of Criticals	0	a	2	э	
Number of Minors	٥	ت	э	٥	
Number of Cavities	3	ے	ξ	3	
Number of Good Shells	52	99	ī	9	
Number of Shells with Porosity & crystallization	1	0	0	09	

A Shells 1, 2, 3, 5, 6, 56, 57, a . '8 ordeted, los pour.

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Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Time	7.5	7.5	7.5	75	
Average Cooling Bay Temp.	93	93	93	93	

X-Ray Preults

Number of Shells Poured	09	09	09	9ور	
Number of Criticals	۲,	=	12	13	
Number of Minors	c	7	_	80	
Number of Cavities	3	9.	15	21	
lumber of Good Shells	88	777	45	39	
Number of Shells with Porosity & crystallization	د	٥	ر	0	

J 3 10/1/73 TEST CNOUP TEST NUMBER TEST DATE

5 4 10/1/7

TEST GROUP TEST NUMBER TEST DATE

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	13
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	10
	6
	Skid Number

Multipour Date

Reservoir Temperature	196	196	187	186	_
Cup Temperature	194	361	184	:82	
Material Temperature	188	187	189	188	
Shell Temperature	<u>%</u>	90	93	76	
Time Poured	7:15	7:19	7.36	7:40	
Duration of Pour	97	53	37	39	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-9	3-10	3-11	3-12	
Length of Shroud Time	18	11	7.5	75	
Average Cooling Bay Temp.	93	66	93	93	

X-Ray Results

Number of Shells Poured	99	99	S94	99	
Number of Crificals	10	18	52	97	·
Number of Mirors	33	36	>	ot	
Mumber of Cavities	4.7	52	Rζ	85	
Number of Good Shells	:3	8	7	7	
Number of Shells with Porosity 6 crystallization	۰.	0	0	0	

A Shell 3 omitted from test, low pour.

Cooling Bay Data

7 54

7:51

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77 7

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Duration of Pour Multipour Number

Time Poured

183

183 185 2

186 182 18

186 :83 186

Reservoir Temperature

Material Temperature Cuo Temperature

Shell Temperature

Multipour Date

8

Cooling Bay - Position	3-13	3-14	7-7	7-5	
Length of Shroud Time	75	7.5	52	۶٤	
Average Cooling Bay Temp.	93	93	8.5	85	

Number of Shells Poured	96	ပ္ခ	.	9	
Number of Criticals	ت	٥	٥	U	
Number of Minors	•	0	0	0	
Number of Cavities	ء	c	1	0	
Number of Good Shells	99	9ن	09	09	
Number of Shells with Porosity & crystallization	0	c	G	ı	

TEST GROUP
TEST NUMBER ...
TEST DATE ... 1773

1771 ii.		2
TEST DATE		Skid Number
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Skid Number		22		
Multipour Data	Data			
Reservoir Temperature	186	186		
Cup Temperature	183	182		
Material femperature	184	185		
Shell Temperature	72	2		
Time Poured	7:58	10.8	 	
Duration of Pour	07	38		
Multipour Number	2	2		

Cooling Bay Data

Cooling Bay - Position	4-3	4-4		
Length of Shroud Time	7.5	7.5		
Average Cooling Bay Temp.	85	85		

Mumber of Shells Poured	09	3	
Number of Criticals	7	~	
Number of Minors	0	0	
Mumber of Cavities	7	2	
Number of Good Shells	95	58	
Mumber of Shells with Porosity 6 crystallization	0	C	

TEST GROUP J TEST NUMBER 5 TEST DATE 10/2/73

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Multipour Data (First Pour)

Reservoir Temperature	186	184	182	183	
Cup Temperature	179	178	621	178	
Material Temperature	184	184	180	184	
Shell Temperature	82	83	82	18	
Time Poured	5:20	5:25	5:52	5:56	
Duration of Pour	37	36	38	38	
Hultipour Number	۲,	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature		•	•		
Cup Temperature					
Materia: Temperature	•	•		,	
Time Poured		•	•	•	
Duration of Pour					
Multipour Number	•	•	•	,	

Core Melting Date

Time Start	5:25	5:30	5:57 6:01	6:01	
Time Probe Down		•	•	-	
Time Pinish	5:27:30	5:32:30	5:27:30 5:32:30 5:59:30 6:03:30	6:03:30	
Duration of Probe	2.5	2.5	2.5	2.5	
Probe Temperature	-	•	•	•	
Probc Steam Pressure	5	\$	\$	5	
Probe Unit Number	7	J	4	4	

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TEST GROUP TEST NUMBER TEST DATE

5 10/2/73

Cooling Bay Data

4-7

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6-3 73 9

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Cooling Bay - Position

Length of Shroud Time

9

5

22 8

X-Ray Results

8 2

Average Cooling Bay Temp.

9 0 0 8 0 0 9 0 ž 0 ~ Number of Shells Poured Number of Criticals Number of Minors

Shell 9 omitted from test, low pour. Number of Shells with Porosity 6 Crystallization

TEST GROUP J TEST NUMBER 6 TEST DATE 10/

10/2/73

Multipour Data (First Pour)

Skid Number

6 15 182 187 176 83 39 11.9 182 178 63 39 6 08 178 781 182 8 38 6:01 178 182 ă 83 Reservoir Temperature Haterial Temperature Shell Temperature Multipour Number Duration of Pour Cup Temperature Time Poured

Multipour Date (Second Pour)

Reservoir Temperature Material Temperature Multipour Number Duration of Pour Cup Temperature fime Poured

Core Melting Date

6 - 20 6 20 15 91 9 6:06.15 6-13:15 5:16:15 • 4 6.13 • ~ ا ۾ ~ 4 Probe Steam Pressure Probe Temperature Probe Unit Number Duration of Probe Time Probe Down Time Finish Time Start

Number of Good Shells

Mumber of Cavities

9

9 0

59 0

23

0

~

0

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0

TEST GROUP J TEST NUMBER 6 TEST DATE 10/2/73

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ld Number
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Cooling Bay Data

Cooling Bay - Pusit, on	71-7	4-13	4-12	7-11	
Length of Shroud) ime	75	75	27	2	
Average Cooling Bay Temp.	96	06	8	8	

X-Ray Results

Number of Shells Poured	594	598	09	9	
Number of Criticals	7	°	0	3	
Number of Minors	0	٥	_	,	
Number of Cavities	-	o	2	9	
Number of Good Shells	58	65	59	54	
Mumber of Shells with Porosity 6 Crystallization	0	°	0	0	

A Shell 55 omitted from test, low pour. B Shell 55 omitted from test, low pour.

TEST CROUP J

10/2/73	
IEST DATE	

Skid Number

Multipour Data (First Pour)

Reservoir Temperature	- 182	182	182	182	
Cup Temperature	8/1	178	182	178	
Material Temperature	186	18	183	183	
Shell Temperature	83	82	82	83	
Time Poured	6:52	6:55	6:58	7:08	
Duration of Pour	23	38	38	38	
Multipour Number	~	~	2	2	!

Multipour Date (Second Pour)

Reservoir Temperature	•	•	•		
Cup Temperature	•	1	-		
Material Temperature					
Time Poured	-				
Duration of Pour	_				
Multipour Number	-				
				•	

Core Melting Date

Time Start	6.57	7:80	7:04	7:11	
Time Probe Down			-		
lime Finish	6: 59: 30	7:02:30	6:59:30 7:02:30 7:06:30 7:13:30	7:13:30	
Duration of Probe	2.5	2.5	2.5	2.5	
Probe Temperature					
Probe Steam Pressure	۶	2	~	\$	
Probe Unit Number	7	7	,		

TEST GROUS J TEST NUMBER 7 TEST DATE 10/2/73

18
17
91
15
1 Number
Skic

Cooling Bay Data

Cooling Bay - Pusition	34	3-5	3.6	3-7	
Length of Shroud Time	75	52	52	7.5	
Average Cooling Bay Temp.	95	76	76	76	

X-Ray Results

Number of Shells Pource	09	09	9	9	
Number of Criticals .	3	~	7	=	
Musber of Minors	۰	ſ,	2	3	
Number of Cavities	12	4	7	15	
Number of Good Shells	87	95	75	97	
Number of Shells with Porosity & Crystallization	0	0	0	0	

TEST GROUP 1 TEST NUMBER 8 TEST NAT 100

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17/01		
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	19 20 21 2:
	Skid Number

Multipour Data (First Pour)

Reservoir Temperature	7	183	184	134	
Cup Trupesature	378	177	178	178	
Material Temperature	184	781	184	184	
Shell Temperature	83	-	84	63	
Time Poured.	7 11	3 , 5	2 40	7 40 7 42	
Duration of Pour	38	€7	39	0**	
Multipour Number	2	2	۲.	۲,	

Multipour Date (Serond Pour)

Reservois Temperature	•	•	•	-	
Cup Temperature	•		•	•	
Materia: Temperature			•	٠	
Time Poured			•	•	
Duration of Pour	•	•	-	•	-
Multipour Number		٠	•	•	

Core Melting Data

Time Start	7 15	7 41	7 41 7-45	٠.٠	
Time Probe Down	•	•	-	•	
Time Finish	21-16-19	31 17-6	7.16 18 7-41 15 7 45 15 7 47 15	7 -7 15	
Duration of Probe	-	-	•	•	
Probe Terperature	•	•		•	
Probe Steam Pressure	ş	ş	\$	\$	
Probe Unit Number	7	7	7	•	

TEST CROUP ...
TEST NUMBER 8
TEST DATE 10/2/73

Cooling Bay Data

 Cooling Bay - Position 	3-8	3-9	01-€	3-11	
Lengtl, of Shroud Time	2,5	7.5	52	7.5	
Average Couling Bay Temp.	76	76	93	76	

X-Ray Results

Number of Shells Poured	09	09	09	09	
Number of Criticals	ĵ.	0	\$	7	
Number of Minors	2	16	6		
Number of Cavities	\$	17	71	11	
Number of Good Shells	55	77	97	67	
Number of Shells with Porosity & Crystallization	0	0	0	0	

TEST CHOUP J TEST NUMBER 9 TEST DATE 10/2/73

		14
		13
		2
1		_
		Skid Number
	1	

Multipour Date (First Pour)

Reservoir Temperature	189	182	182	182	
Cup Temperature	178	178	178	178	
Material Temperature	183	182	182	181	
Shell Temperature	82	28	83	83	
Time Poured	5:16	17.9	6.45	67.9	
Duration of Pour	-	07	17	17	
Multipour Number	2	2	2	2	

Cooling Bay Date

Cooling Bay - Position	4-1	3-1	2−€	3+3	
Length of Shroud Time	7.5	7.5	7.5	7.5	
Average Cooling Bay Temp.	8	95	95	9.8	

X-Kay Results

Number of Shells Poused	894	09	09	09	
Number of Criticals	0	0	0	0	
Number of Minors	۶	0	2	0	
Number of Covities	\$	0	2	0	
Number of Good Shells	54	09	85	09	
Number of Shells with Porosity 6 crystallization	0	0.	0	0	

A Shell 9 omitted, low pour.

THE PROPERTY OF THE PROPERTY O

TEST GROUP 1 TEST NUMBER 10 TEST DATE 1(3)31	
TEST GROUP J 1.35T NUMBER 10 TEST DATE 10/3/73	

18.	TEST INTER	10 10/3/73				
Skid Number	_	,,	3	,	Š	Skid Number
Multipour Date	Date					
Res. : voir Temperature	176	176	176	176	176	Reservoir
Cub Tesperature	174	174	174	174	174	Cun Temper
Material Temperature	176	176	176	921	175	Material T
Shell Temperature	29	61	62	81	7.8	Shell Temp
Time Poured	5.26	5.31	5.37	62.5	\$ 46	Time Poure
Duration of Pour	\$	17	17	\$7	£.4	Duration o
Multipour Number		~	~	č	2	Multipour

Pultipour Data	Data				
Reservoir Temperature	176	176	92.	921	174
Cuo Temperature	17.	17-	۳٤,	174	7,1
Material Temperature	175	176	١-٠	,	17.6
Shell Temperature	70	٤٠	7.5	٠,	70
Time Poured	د دن	\$ \$ \$	6.13	0 9	6 1.
Duration of Pour	ر دي	4.2	30	٠.5	77
Mult:pour Number	~	:	7	ï	~

,						L
3-5	Cooling Bay - Position	3-6	3-7	3-8	1.9	
%	Length of Shroud Tire	7,	×	34	٠,	
3	Average Coling Bav Temp.	,	76	3	20	•
						l

34

76 5

Average Cooling Bay Temp.

X-Ray Results

3.3

3-5

3-1

Cooling Bay - Position Length of Shroud Time

Cooling Bay Data

X-Ray Results

Cooling Bay Data

Mumber of Shells Poured	60	9	99	99	99
Mumber of Criticals	0	0	v	O	c
Number of Minors	0	0	0)	0
Number of Cavities	0	0	0	3	o
Number of Good Shells	09	09	09	90	09
Number of Shells with Porosity 6 crystallization	0	0	0	0	0

Number of Shells Poured	119	45.	٤	ĭ	14
Number of Criticals	ر	-		,	.
Number of Minors	=	١	a	ı	ij
Number of Cavities	7	,	,	1	,
Number of Good Shells	90	\$\$.09	1)9	99
Number of Shell with Porosity 6 crystallization	0	0	0	0	٥

A Shells 6, 30, 36, ...?, 60 cmitted, low pour.

THE SECOND PROPERTY OF THE PRO

TEST GROUF
TEST NUMP_R
TEST LAFE

1 11 10/3,73

2 13

Skid Number

Mu tipour Data (First Pour)

Reservoir Temperature 176 175 175 176 Cup Temperature 173 172 179 178 Haterial Temperature 175 174 175 175 Shell Temperature 95 95 93 90 Time Poured 6:54 7 00 7:07 7 14 Duration of Pour 65 49 51 50 Hulltpour Number 2 2 2 2						
173 172 179 ste 175 174 175 95 95 93 93 6:54 7 00 7:07 65 49 51 2 2 2	Reservoir Temperature	176	176	175	176	
ste 175 174 175 95 95 93 6:54 7 00 7:07 65 49 51 2 2 2	Cup Temperature	173	172	179	178	
95 95 93 6:54 7 00 7:07 65 49 51 2 2 2	Material Temperature	175	7/1	175	175	
6:54 7 00 7:07 65 49 51 2 2 2	Shell Temperature	95	\$6	63	95	
65 49 51	Time Poured	95:9	00 2	20:2	7 14	
Hultipour Number 2 2 2 2	Duration of Pour	65	67	5.1	8	
	Hultipour Number	2	2	2	2	

Multipour Date (Second Pour)

Reservoir Temperature	•	•	•		
Cup Temperature	•	•		•	
Material Temperature	•	•	•	•	
Time Poured	•	•	•	•	
Duration of Pour	•	,	,		
Hultipour Number	•		•		

Core Melting Data

Time Start	7:00		7 05 7 12 7 19	7 19	
Time Probe Down	•	•	•	,	
Time Finish	7 02:30	7,07 30	7 14 30	7 42:30 7,07 30 7 14 30 7 21-30	
Duration of Probe	2.5	2.5	2.5	2.5	
Probe Temperature	218	-			
Probe Steam Pressure	\$	\$	5	S	
Probe Unit Number	7	7	3	7	

THE PARTY PROPERTY OF THE PROP

ا 11 10/3/7 TEST GROUP TEST NUMBER TEST DATE

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Cooling Bay Lata

Cooling Bay - Position	1-7	7-7	4-3	4-4	
Length of Shroud Time	7.5	7.	7.5	2.5	
Average Cooling Bay Temp.	26	69	06	06	

Number of Shells Poured	90	60	90	99	
Number of Criticals	0	2		0	
Number of Minors	10	8	9	\$	
Number of Cavities	£1	01	2	9	
Number of Good Shells	0\$	υS	83	54	
Number of Shells with Porosity & Crystallization	ú	0	Ų	0	

TEST GOOP J TEST HUMBER 12 1EST DATE 10/3/73

ŀ	oz
	18
	17
	16
	Skid Number

Mult	Multipour Data (First Pour)	(First Pot	(i,		
Reservoir Temperature	179	188	180	179	
Cup Temperature	180	180	178	178	
Material Temperature	176	176	178	177	
Shell Temperature	06	91	92	16	
Time Poured	2.	7.34	7 45	7 54	
Duration of Four	;	57		57	
Hultfpour Number	~	2	23	2	

Multipour Date (Second Pour)

Reservoir Temperature Cup Temper ture Mater: Temperature Time ored Duration of Pour Multipour Number						
Cup Tempor iture Mater Temperature Time oved Duration of Pour Multipour Number	Reservoir Temperature	•	•	•	•	
Mater Temperature Time Act of Pour Multipour Number	Cup Temperature		-	-	•	
Tiec red Duration of Pour Multipour Number			•	•	•	
Duration of Pour	Time ''red				•	
Multipour Number	Duration of Pour		•	•	•	
	Multipour Number			•	-	

Core Melting Duta

Time Scart	1.29	7.39	7 50	7.30	
Time Probe Down		•	•		
Time Finish	7 34	7 44	35 5	8 04	
Duration of Probe	\$	۶	۶	\$	
Probe Temperature	220	220	220	220	
Probe Steam Pressure		s	\$	۶	
Probe Unit Number	7	7	7	7	

TEST GROUP J TEST NUMBER 12 TEST DATE 10/3/79

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	20
	81
	17
	16
	kid Number

Cooling Bay Data

Cooling Bay - Position	, , ,	4-4	7-7	01-7	
		3	:	;	
rengen of ontone that	- 27	18	3	\$	
Average Cooling Bay Temp.	8	87	89	96	

Number of Shells Fourad	\$2A	99	60	9	
Number of Criticals	0	1	1	0	
Number of Minors	1	7	11	2	
Number of Cavities	2	\$	20	ε	
Number of Good Shells	51	\$\$	87	58	
Number of Shells with Porceity & Grystallization	0	0	0	0	

A Shells 6, 24, 30, 36, 42, 48, 54, and 60, low pour.

TEST GROUP TEST NUMBER TEST DATE

ر 13 10/3/3

61
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Number
Skir

(100		, , , ,	
Reservoir Temperature	174	180	Γ
Cup Temperature	174	177	Τ
daterial Temperature	27.5	177	Τ
Shell Temperature	06	06	Τ
Time Poured	61:9	7.50	Т
Duration of Pour	45	27	7
Multipolur Number	2	~	Τ
			-

Skid Number

J 14 10/4/73

TEST GROUP TEST NUMBER TEST DATE

Multipour Data	Data				
Reservoir Temperature	175	175	1,52	175	13
Cup Temperature	174	175	174	27.	7.7
Material Temperature	176	176	176	176	2,2
Shell Temperature	7.5	92	92	32	۾
Time Poured	5.40	77:5	67:	5.53	\$:5
Duration of Pour	115	98	52	51	22
Multipour Number	2	2	,	,	,

Cooling Bay Data

7		
71-7	75	16
3-11	75	76
 Cooling Bay · Position	Length of Shroud Time	Average Cooling Bay Temp.

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	7-6	3-5
Length of Shroud Time	7.5	75	7.5	25	z
Average Cooling Bay Temp.	86	86	86	86	98

X-Rey Results

09

3

Number of Shells Poured

Number of Criticals

X-Ray Results

50 22 39

> =| 20

> > Number of Shells with Porosity & crystallization

Number of Grad Shells

Number of Cavit.es Number of Minors

Number of Shells Pourse.	400	9	- "		
	270	20	2	3	9
Number of Criticals	•	0	0	٥	٥
Number of Hinors	0	٥	۰	0	·
Number of Cavities	•	0	٥	S	•
Number of Good Shells	59	09	99	9] 8
Number of Shells with Porosity & cruesall caster	٥	٥	0	°	

A Shell 2 omitted, low pour.

TEST CROUP TEST NUMBER TEST DATE

Skid Number

Multipour Data

Reservoir Temperature	175	521	\$21	\$41	\$41
Cup lemperature	174	7/1	721	175	721
Material Temperature	176	176	178	177	177
Shell Temperature	11	11	u	11	11
Time Poured	6:00	90.9	60.9	6.13	6:16
Duretion of Pour	67	50	57	97	\$\$
Multipour Number	2	2	2	2	. 2

TEST CROUP TEST NUMBER TEST DATE

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Multipour Data

Reservoir Temperature 174 175 175 175 175 175 175 177 178 174 175						
ture 176 178 179 178 e 78 178 177 178 e 6.46 6.52 6.36 7.00 90 68 58 45	Reservoir Temperature	174	175	175	175	175
ture 176 176 177 178 178 178 178 178 178 178 179 179 179 179 179 179 179 179 179 179	Cup Temperature	176	178	179	178	7/1
6:46 6.52 6:56 7·00 90 68 58 45	Material Temperature	:76	176	771	178	175
6:46 6.52 6:36 7·00 90 68 58 45 1 1 1	Shell Temperature	78	78	22	2.5	91
57 88 89 06	Time Poured	6:46	6.52	95:9	7 · 00	7 - 05
Multipour Number 1 1 2	Duration of Pour	90	68	88	45	\$\$
	Multipour Number	-	1	1		2

Cooling Bay Data

Cooling Bay - Position	3-11	3-12	3-13	3-14	3-14 4-1
Length of Shroud Time	2,2	7.5	7.5	2,2	75
Average Cooling Bay Temp.	98	86	98	98	87

3-10

3-9

3-8 22 8

3-7

3-6

Cooling Bay - Position Length of Shroud Time

Cooling Bay Data

2 82

23 86

Average Cooling Bay Temp.

2 87 X-Ray Results

88€

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9

8

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Number of Shells Poured

Number of Criticals

X-Ray Results

0 0 0

0 0 0

0 0

Г	Number of Shells Poured	54A	895	28C	60	165
Г	Number of Criticals	0	0	0	0	0
Ι_	Number of Minors	0	0	0	0	0
Г	Number of Cavities	0	0	0	0	0
Ι	Number of Good Shells	54	95	88	99	65
	Number of Shells with Porosity 6 crystallization	0	0	0	v	09

29

9

3

9

ş

Number of Good Shells

Mumber of Cavities Mumber of Minora

0 0

0

0

0

0

0

A Shell 15 omitted, low pour.

Maber of Shells with Porosity 6 crystallization

Shells 15, 21, 26, 31, 33, and 59 omitted, low pour. Shells 17, 23, 34, and 53 omitted, low pour. Ablis 10 and 29 omitted, low pour. Shell 2 omittee, low pour.

HELMAN OF THE STATE OF THE STAT

י	21	10/4/73
CROUP	NUMBER	DATE
TEST	1231	1221

Skid Mumber	91	17	81	19	20
Hultipour Data	Data				
Reservoir Temperature	174	176	178	180	180
Cup Temperature	174	921	174	174	721
Material Temperature	175	921	177	176	177
Shell Temperature	۲٠	91	8,	"	"
Time Poured	7:11	7 17	7 21	1 25	7.36
Duration of Pour	47	3 5	57	5,5	47
Multipour Number	2	2	21	~	1

2:19

2 15

35

1 53

. 50

67

2

~

2

73

92

92

2

4-5

,-,

4-3

4-2

7-7 2

Cooling Bay - Position

Length of Shroud Time

Cooling Bay Date

2 25

73

7.5

22

8

Average Cooling Bay Temp.

X-Ray Results

177

177

176

177 175

178 175

174 175 177

174

Reservoir Temperature

Material Temperatura

Cup Temperature

Shell Temperature

Duration of Pour Multipour Number

Time Poured

Multipour Data

J 16 10/5/73

TEST CROUP TEST NUMBER TEST DATE

175 174

> 2 =

Cooling	Cooling Bay Data			
ing Bay - Yosition	7-7	6-4	7-7	**
h of Shroud Time	78	5,2	75	3,
# # # #	Ş	,,	;	

Cooling Day - Position	4-2	4-3	7-7	\$-5	9-7
Length of Shroud Time	78	7.5	7.5	7.	2
Average Cooling Bay Temp.	87	86	86	87	1 %
Mumber of Shells Poured	g	Ç9	09	9	\$
Mumber of Criticals	0	٥	0	٥	0
Mumber of Minors	0	0	0	•	0

	9	હ	09	9	V6 \$
Number of Criticals	0	٥	0	0	٥
Mumber of Minors	0	0	0	0	0
Number of Cavities	0	0	-	٥	0
Mumber of Good Shells	09	09	09	09	59
Number of Shells with Porosity & crystalitzation	0	0	1	0	0

9 8 () 0 0 0 9 9 0 o 0 د، 9 9 0 0 ت 3 9 0 c ပ n Number of Shells with Porosity & crystallization Number of Shells Poured Number of Good Shells Number of Criticals Number of Cavities Number of Minors

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TEST CROUP J.
TEST NUMBER 16
TEST DATE 10/5/73

Multipour Data

Band anodanasu					
Reservoir Temperature	177	177	176	176	176
Cup Temperature	17,	176	177	176	176
Material Temporature	177	177	7.21	178	179
Shell Temperature	"	92	11	92	7.5
Time Poured	2:23	2 25	2.28	2.30	2:33
Duration of Pour	87	45	46	•	77
Multipour Number	2	2	2	2	2

Cooling Day Date

Cooling Bay - Fosition 4-6 4-7	8-7	6-7	01-7
1.5 15 75 75 75 75	75	75	75
Average Cooling Bay Temp. 95 95	95	95	95

X-Nay Results

Number of Shells Poured	9	60	99	90	9
Number of Criticals	٥	a	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	09	09	09	09	9
Number of Shells with	٥	0	0	0	0
יייייייייייייייייייייייייייייייייייייי					

TEST GROUP J TEST NUMBER 16 TEST DATE 10/5/73

Section 1

Skid Number	11	12	22	14	15
Multipour Data	Date				
Reservoir Temperature	176	176	176	176	176
Cup Temperature	176	176	176	176	111
Material Temperature	771	771	177	177	177
Shell Temperature	76	75	2,2	76	75
Time Poured	. 2:35	2:38	15:2	2:44	2:46
Duration of Pour	43	•	57	47	80
	,	2	2	7	7

Cooling Bay Data

Cooling Ray - Position	11-7	4-12	4-13	- 1	4-14 5-1
Length of Shroud Time	7.5	7.5	75	75	25
Average Cooling Bay Temp.	- 95	95		8	

Number of Shells Poured	9	9	09	60	9
Number of Criticals	0	0	0	0	0
Number of Minors	٥	0	0	0	٥
Number of Cavities	۰	0	0	0	اہ
Number of Good Shells	9	09	99	99	ŝ
Rumber of Shells with		٥	0	0	•

J 16 10/5/73 TEST CROUP TEST NUMBER TEST DATE

17
16
Skid Number

Multipour Date

Reservoir Temperature	176	176	
Cup Temperature	177	177	
Material Temperature	177	177	
Shell Temperature	75	7.5	
. Time Poured	2.49	2 52	
Duration of Pour	87	£7	
Multipour Number	2	2	

; 17 10/8/73 TEST :ROUP TEST N'MBER TEST 2º (E

1 2 3 4

Multipour Data (First Pour)

Reservois Temperature	184	184	184	182	281
Cup Temperature	180	178	178	178	179
Material Temperature	160	180	181	180	179
Shell Temperature	78	76	7.5	76	76
Time Poured	5.34	5 37	5:40	5:45	5:49
Duration of Pour	40	07	41	38	07
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	4-1	4-2	6-3	7-7	5-7
Length of Shroud Time	7.5	75	75	22	52
Average Cooling bay Temp.	89	89	80	68	68

22

8

Average Cooling Bay Temp.

2-5

Cooling Bay - Position Length of Shroud Time

Number of Shells Poured	09	60	SEA	8	9
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	٥
Number of Cavities	0	0	0	0	٥
Number of Good Shells	09	09	88	09	9
Number of Shells with Porosity 6 crystallization	0	0	0	0	۰

A Shells 49 and 55 omitted.

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8 0

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Number of Shells Poured

Number of Criticals

X-Ray Results

0

Number of Shells with Porosity & crystallization

Number of Good Shells

Number of Cavities Number of Minors

Cooling Bay Data

J 18 10/8/73 TEST CHOUP TEST KINGER TEST DATE

(TOT TOTAL) BONG CONTROLL					
Meservoir Temperature	182	1 82	182	182	162
Cup Temperature	180	180	170	180	180
Material Temperature	180	180	180	185	180
Shall Temperature	85	84	88	78	82
Time Poured	4:01	6:05	90:9	60:9	6:12
Duration of Pour	17	40	77	43	77
Multipour Number	2	2	7	2	2

Cooling Bay - Position	4-6	4-7	4-8	6-5	4-10
Longth of Shroud Time	7.5	52	7.5	7.5	54
Average Cooling Bay Temp.	%	06	89	68	68

X-Ray Results

Mumber of Shells Poured	60	09	60	59.4	57B
Number of Criticals	0	0	0	0	0
Mumber of Minors	0	0	1	0	0
Number of Cavities	0	0	1	0	0
Mumber of Good Shells	60	09	59	09	9
Number of Shells with Porcetty & crystallization	0	Q	0	0	0

A Shell 42 was omitted from the test.

B Shells 5, 36, and 42 were omitted from the test.

J 19 10/8/73 TEST GROUP TEST NUMBER TEST DATE

, ,

Skid Number	11	12	13	14	51
Multipour Data (First Pour)	Data (Fire	st Pour)			
Reservoir Temperature	186	187	190	190	190
Cup Temperature	179	182	184	184	184
Material Temperature	182	184	184	183	183
Shell Temperature	9/	92	77	9,6	78

Cooling Bay Data

45

77

3

3

Duration of Pour Multipour Number

Time Poured

Cooling Bay - Position	4-11	4-12	4-13	4-12 4-13 4-14	3-1
Length of Shroud Time	75	7.5	7.5	75	75
Average Cooling Bay Temp.	88	88	85	89	86

Number of Shells Poured	09	60	90	29A	09
Number of Criticals	0	١	0	0	2
Number of Minors	0	0	0	0	2
Number of Cavities	0	0	0	0	7
Number of Good Shells	09	09	09	59	26
Number of Shells with Porosity & crystallization	0	0	0	0	0

TEST CROUP J TEST NUMBER 19 TEST DAIE 10/8/?3

21 Skid Number

Multipour Data (First Pour)

	/ vno	/ 100
Reservoir Temperature	190	
Cup Temperature	184	
Material Temperature	184	
Shell Temperature	" "	
Time Poured	7:39	
Duration of Pour	39	
Multipour Number	2	

Cooling Bay Date

Length of Shroud Time 75 Average Cooling Bay Temp. 87	Cooling Bay - Position	3-7	
Average Cooling Bay Temp. 87	Length of Shroud Time	7>	
	Average Cooling Bay Temp.	87	

X-Ray Results

Number of Shells Poured	09	
Number of Criticals	0	
Number of Minors	0	
Number of Covities	0	
Number of Good Shells	8	
Number of Shells with Porocity & crystallization	0	

j 20 10/8/73 TEST CHOUP TEST NUMBER TEST DATE

20
2
2
2
16
Skid Number

Multipour Data (First Pour)	Date (Fir	st Pour)			
Reservoir Temperature	190	190	061	180	8
.Cup Temperature	781	184	184	184	184
Material Temperature	184	185	185	163	791
Shell Temperature	76	83	84	84	82
Time Poured	7:23	7:27	7:30	7:32	7:35
Duration of Pour	41	40	07	41	39
Multipour Number	2	2	2	2	2

Cooling Bay Data

Cooling Bay - Posttion	3-2	3-3	3-4	3-5	3-6
Length of Shroud Time	7.5	75	7.5	75	7.5
Average Cooling Bay Temp.	98	87	98	98	87

Number of Shells Poured	9	09	09	09	09
Number of Criticals	2	ε	0	5	7
Number of Minors	7	0	1	æ	0
Number of Cavities	9	3	2	13	-
Number of Good Shells	3,4	57	55	47	59
Number of Shells with Porosity 6 crystallization	0	0	٥	0	o

TEST CHOUP TEST NUMBER TEST DATE

Jan 1

	Skid Number	
ſ	7	
-	22	
-		
	Skid Number	

Skid Number	22	 	
Multipour Date	Date		
Reservoir Temperature	190		
Cup Temperature	184		
Material Temperature	186		
Shell Temperature	85		
Time Poured	7:42		
Duration of Pour	. 9		
Multipour Number	2		

			ŀ		
Reservoir Temperature	190		_		Reservoir Tempera
Cup Temperature	184				Cup Temperature
Material Temperature	186				Haterial Temperat
Shell Temperature	85				Shell Temperature
Time Poured	7:42				Time Poured
Duration of Pour	. 9				Duration of Pour
Hultipour Number	2				Multipour Number
		1000 (C) (C)			

Cooling Bay - Position 3-8 Length of Shroud Time 75

	3-6	
Length of Shroud Iime	75	
Average Cooling Bay Temp.	87	
•		
a-×	X-Ray Results	

Number of Shells Poured	99	
Number of Criticals	0	
Number of Minors	3	
Number of Cavities	8	
Number of Good Shells	52	
Masber of Shells with Porceity & crystallization	0	

	Cooling Bay Data	

5:45

5:41

5:34

5:29

. 5:20

92

25

ç3

63

73

7,4

80

176

176

176 176 177 80

176 176 178

176 176 178 2

Reservoir Temperature

Material Temperature Shell Temporature

Multipour Data (First Pour)

TEST CHOUP TEST NUMBER TEST DATE

180 176

177

Cooling Bay - Position	3-1	3-2	3-3	3-4	3-5
Length of Shroud Time	7.5	7.5	7.5	7.5	2,2
Average Cooling Bay Temp.	86	98	86	8,	98

X-Ray Results

Number of Shells Poured	99	50	09	60	90
Mumber of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	09	60	09	99	09
Number of Shells with Porosity & crystallization	0	0	0	0	0

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TEST CHOUP TEST NUMBER TOLT DATE

5 21 10/11/73

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A CONTRACTOR OF THE PERSON OF	Skid Number

Multipour Data (First Pour)

Meservoir Temperature	176	7/1	174	176	177
Cup Temperature	176	176	176	176	174
Material Temperature	179	641	179	178	179
Shell Temperature	11	7.8	7,	79	79
Time Foured	5:51	5:59	6:07	6:14	6:19
Duration of Pour	35	87	72	09	
Multipour Number	1	2	2	2	2

Cooling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-16
Length of Shroud Time	7.5	\$1	7.5	7,5	2
Average Cooling Bay Temp.	86	98	87	87	87

X-Ray Results

Number of Shells Poured	99	09	09	09	ş
Number of Criticals	0	0	0	٥	٥
Mumber of Minors	0	0	0	٥	۰
Number of Cavities	0	٥	0	۰	۰
Number of Good Shells	09	09	09	09	3
Number of Shells with Porosity & crystallization	0	ō	0	0	0

TEST CROUP TEST NUMBER TEST DATE

Skid Number	11		
Multipour Date	Date		
Reservoir Temperature	184		
Cup Temperature	521		
Material Temperature	178		
Shell Temperature	80		
Time Poured	7:03		
Duration of Pour	70		
Multinour Number	2		

Cooling Bay Data

Cooling Bay - Position	3-11	 	
Length of Shroud Time	بامو		
Average Cooling Bay Temp.	88		

Number of Shells Poured	99		
Number of Criticals	0		
Number of Minors	٥		
Mumber of Cavities	0		
Number of Good Shells	09		
Number of Shells with Porosity & crystallization	0		

GROUP K

TEST 21

There were 60 critical and 97 minor defects found.

Probe machine 4 had a temporary curtain installed around the sides and the back (about 3 - 4 feet high). The purpose of the curtain was to prevent any drafts from cooling the shells. Skid 17 was probed in machine 3 which did not have a curtain. The skid had 26 good shells versus the 18 - 20 good shells per skid for the other skids in the test. Skid 17 also had the highest steel temperature of any skid in this test. It is possible that the curtain does not help, but in any case a defect level this high is unacceptable.

TEST 22

There were 10 critical and 44 minor defects found. As in Test 21 three of the four skids were probed in the machine which had a temporary curtain installed around it. The fourth skid (number 8) was probed in unit 3 which did not have a curtain. As in Test 21 the skid had a lower percentage of defective shells.

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TEST 23

There were 11 criticals and 33 minor defects found on the 2 skids in this test.

GROUP K PROBING

Test	Probe Time	Number of Skids
21	5	4
22	15	4
23	No probe	1

NOTES:

- 1. Material containing 40% scrap was used.
- 2. An additional agitator was used in the reservoir and a minimum lower level limit was maintained. Steel temperature was 88° to 92°F.
- 3.
- Explosive temperature was 178 to 182°F. 4.
- 5. Picatinny shroud was used.
- 6. The cooling bay temperature was ambient and recorded.
- Shroud time was 1.25 hours from time of pour. 7.
- 8. Total cooling time was 3.75 hours.
- 9. All shells were 100% X-rayed.
- The probe depth was 4 inches above the breakoff point. 10.
- Probing was started 5+1 minutes after pouring. 11.
- The bottom of the probe machine was curtained off while probing except for 1 skid in Test 22.

K 21 10/9/7J TEST GROUP
TEST NUMBER
TEST DATE

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	19
1	18
	1,
1	9;
	Skid Number

Multipour Data (First Pour)

Reservoir Temperature	183	184	184	781	
Cup Temperature	182	182	180	182	
Material Temperature	180	180	091	081	
Shell Tesperature	16	06	68	16	
Time Poured	7:32	7-35	7:38	7.45	
Duration of Pour	67	17	07	38	
Multipour Manuer	~	2	2	۲,	

Multipour Date (Second Pour)

Meservoir Temperature	•	•	•	•	
Cup Temperature	•	-	,	'	
Material Temperature	•		,	ı	
Time Fourad .	•	•		•	
Duration of Pour	•	-	•	٠	
Multipour Masber	•	•	•	•	

Core Melting Data

Time Start	7:37	2:40	7:43	7:50	
Time Probe Down	0	0	0	0	
Time Pinish	7:42	7:45	7:48	7:55	
Duration of Probe	s	\$	\$	5	
Probe Temperature	-	١			
Probe Steam Pressure	۶	•	5	\$	
Probe Unit Number	7	3	7	7	

THE SECTION OF SECTIONS OF SEC

TEST CROUP K
TEST NUMBER 21
TEST DATE 10/9/73

_	
-	19
	18
	17
	91
	Skid Number

Cooling Bsy Data

Cooling Bay - Position	4-4	3-13	4-5	7-6	
Length of Shroud Time	7.5	7.5	2,5	75	
Average Cooling Bay Temp.	06	92	16	91	

Number of Shells Powerd	ور	39	9	6.9	
Number of Criticals	15	- 12	13	20	
Number of Minors	27	22	2.3	21	
Number of Cavities	77	35	63	41	
Number of Good Shells	8;	26	20	o;	
Number of Shells with	0	٥	ပ	9	
Porosity & Crystallization					

K 22 16/9/73 TEST CROUP TEST NUMBER TEST DATE

	12
	8
-	-
d Number	
Sk1	

Multipour Data (First Pour)

182 182 182 176 180 180 179 179 179 90 90 90 5·31 \$ 34 6:63 40 45 45 2 2 2						
ture 179 180 180 e 90 90 90 90 5.31 \$5.54 \$6.63 40 45 45 2 2 2	Teservoir Temperature	182	182	182	183	
Fure 179 179 179 179 179 179 179 179 179 179	Cup Temperature	176	180	180	081	
5.31 5.34 6:63 40 45 45 2 2 2	Haterial Temperature	179	170	1 70		
5·31 5·34 6:63 40 45 45 2 2 2	Shell Temperature	8	ş	<u> </u>	net ,	
5·31 5·54 6:63 40 45 45 2 2 2	Time Borney			2	١	
40 45 45	Daing anti-	5.31	75 v.	3:9	7:07	
Multipour Number 2 2 2 2	Duration of Pour	07	4.5	6.5	41	
	Hultipour Number	2	2	2	7	
	7			_	,	

Multipour Date (Second Pour)

Reservoir Temperature					
	_				
Cup Temperature					
Mcterial Temperature	-				
Time Poured .	T			1	
	1				
Duration of Pour	_	•	•	•	
Multipour Number	-	-			

Core Melting Date

Time Start	5.36	\$:50	8:59 6:08	[
Time Probe Down				,	
Time Finish	5:51	9.14	6.23	7.33	
Duration of Probe .	22	5)	21	2	
Probe Temperature	120			1	
Probe Steam Pressure	~	-		1~	
Probe Unit Number	7	7	,,		

K 22 10/9/73 TEST GROUP
TEST NUMBER
TEST DATE

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	:	12	
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	_		
	10 number		
1	١	!	

Cooling Bay Data

_		
4-3	22	91
3-5	75	92
4-2	2	91
4-1	2,2	16
Cooling Bay - Position	Length of Shroud Time	Average Cooling Bay Temp.

Number of Shells Poured	09	9	09	9	
Number of Cold					
MUMBER OF CRITICALS	e	-	6		
Number of Minors	12	^		=	
Number of Cavities	15	6 0	111	20	
				:	
Number of Good Shells	45	75	67	07	
				}	
Number of Shells with	•	0	n	-	
Porosity & Crystallization		-	•	-	

TEST GACUP K
TEST NUMBER 23
TEST DATE 10/9/73

Skid Number	6	20		

Multipour Data

Reservoir Temperature	182	184		
Cup Temperature	180	182		
Material Temperature	179	182		
Shell Temperature	-	90		
Time Poured	5:57	7:48		
Duration of Pour	45	40	•	
Multipour Number	2	2		

Cooling Bay Data

Cooling Bay - Position	3-4	3-14		
Length of Shroud Time	75	75		
Average Cooling Bay Temp.	92	92		

Number of Shells Poured	60	60		
Number of Criticals	3	9		
Number of Minors	12	21	·	
Number of Cavities	15	30		
Number of Good Shells	45	30		
Number of Shells with Porosity & crystallization	0	0		

TEST GROUP L TEST NUMBER 1 TEST DATE 10/9/73 Skid Nurber 2 3 4

Multipour Data

Meservoir Temperature	182	182	182	
Cup Temperature	177	178	178	
Material Temperature	180	67.1	179	
Shell Temperature	૪	16	8	
Time Poured	5:36	5:44	5:49	
Duration of Pour*	15/30	13/28	16/31	
Mult'pour Number	2	2	2	

Cooling Bay Date

Length of Shroud Time 75
Average Cooling Bay Temp. 92

X-Ray Results

Mumber of Shalls Poured	- -	ç	7,7	
		3	3	
Number of Criticals	11	- 11	٥	
Mumber of Minors	2	۰	٥	
Mumber of Cavities	33	2	٥	
Mumber of Good Shells	27	37	09	
Number of Shells with Porosity & crystallysed	12	0	J	

*First pour/second pour

TEST GROUP L TEST NUMBER 2 TEST DATE 10,9/73

Skid Number	6	10	11	
Multipour Date	Date			
Reservoir Temperature	184	182	183	
Cup Temperature	180	180	180	
Material Temperature	180	180	180	
Shell Temperature	06	8	8	
Time Poured	6:44	6:51	6:56	
Duration of Pour *	13/38	13/31	14/31	
Multiponr Number	2	2	2	

Cooling Bay Data

\$	75	92
3-9	7.5	26
3-6	7.5	92
Cooling Bay - Position	Length of Shroud Time	Average Cooling Bay Temp.

X-Ray Results

Number of Shells Poured	09	99	g	
Number of Criticals	19	22	2	
Number of Minors	11	12	62	
Number of Cavities	36	23	32	
Number of Good Shells	77	ž	28	
Number of Shells with Porosity 6 crystallization	0	c	С	

*First pour/second pour

TEST GROUP L
TEST NUMBER 3
TEST DATE 10

3 10/9/73 THE PROPERTY OF THE PROPERTY O

Skid Number	13	14	15	

Multipour Data

Reservoir Temperature	183	183	183	
Cup Temperature	180	180	180	
Material Temperature	180	182	180	
Shell Temperature .	91	90	90	
Time Poured	7:11	7: <u>1</u> 8	7:24	
Duration of Pour*	12/27	13/29	13/27	
Multipour Number	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-10	3-11	7-17	
Length of Shroud Time	75	75	75	
Average Cooling Bay Temp.	92	93	90	

X-Ray Results

Number of Shells Poured	60	6υ	νO	
Number of Criticals	14	9	17	
Number of Minors	23	17	25	
Number of Cavities	37	27	42	
Number of Good Shells	23	34	18	
Number of Shells with Porosity & crystallization	0	0	1	

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TEST GROUP TEST NUMBER TEST DATE L 3 10/9/73

Skid Number 13 14 15

Multipour Data

Reservoir Temperature	183	183	183	
Cup Temperature	180	180	180	
Material Temperature	180	182	180	
Shell Temperature	91	90	90	
Time Poured	7:11	7:18	7:24	
Duration of Pour*	12/27	13/29	13/27	
Multipour Number	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-10	3-11	3-12	
Length of Shroud Time	7 5	75	75	
Average Cooling Bay Temp.	92	. 93	93	

Number of Shells Poured	60	60	60	
Number of Criticals	14	9	17	
Number of Minors	23	17	. 25	
Number of Cavities	37	27	42	
Number of Good Shells	23	34	18	
Number of Shells with Porosity & crystallization	0	0	1	

^{*}First pour/second pour

TEST CROUP TEST NUMBER TEST DATE

Multipour Data	Data				
Rescrvoir Temperature	186	182	182	180	
Cup Temperature	172	174	174	174	
Material Temperature	179	179	179	179	
Shell Temperature	83	23	83	83	
Time Poured	5:35	5:38	5:42	5:45	
Duration of Pour	39	42	41	57	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bay - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	7.5	7.5	7.5	75	
Average Cooling Bay Tem,	88	88	88	88	

Mumber of Shells Poured	99	9	99	09	
Mumber of Criticals	4	0	2	0	
Number of Minors	4	. 0	0	£	
Number of Cavities	10	0	2	ι	
Number of Good Shells	52	9	58	57	
Number of Shells with Porosity 6 crystallization	0	Ü	0	0	

ж 2 10/10/73 TEST GROUP TEST NUMBER TEST DATE

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Skid Number	s	9	,		
Multipour Date	Date				
Reservoir Temperature	180	182	182	182	
Cup Temperature	177	178	180	180	
Material Temperature	178	180	179	179	
Shell Temperature	82	78	78	\$8	
Time Poured	5:59	50:9	97.9	60:9	
Duration of Pour	17	67	97	57	
Multipour Number	2	2	7	2	

Cooling Bay Data

Cooling Bay - Position	3-5	3-6	3-7	3-8	
Length of Shroud Iime	75	75	7.5	75	
Average Cooling Bay Temp.	88	88	88	88	

Number of Shells Poured	99	9	09	99	
Mumber of Criticals	0	0	0	2	
Number of Minors	0	0	0	2	
humber of Cavities	0	0	0	7	
Number of Good Shells	09	9	09	56 .	
Number of Shells with Porosity & crystallization	0	0	0	0	

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TEST GROUP H
TEST NUMBER 3
TEST DATE 10/10/73

Skid Number 2 ~ Skid Mumber

Multipour Date (First Pour)

Reservoir Temperature	181	182	
Cup Temperature	180	180	
Material Temperature	180	150	
Shell Temperature	86	68	
Time Poured	6:48	90:2	
Duration of Pour	45	97	
Multipour Number	2	2	

Cooling Bay Date

Cooling Bay - Position	3-11	3-12		
Length of Shroud Time	51	25		
Average Cooling Bay Temp.	88	83		

X-Ray Mesults

			ı
Number of Shells Poured	9	9	
Number of Criticals	2	18	
Mumber of Minors	1	15	1
Number of Cavities	3	33	<u> </u>
Number of Good Shells	57	27	Γ
Mumber of S.ells with Porosity 6 c. stallization	0	0	1
			1

TEST GROUP TEST NUMBER TEST DATE

М 4 10/10/75

Multipour Date	Date		
Reservoir Temperature	182	181	
Cup Temperature	081	180	
Material Temperature	180	180	

6:43 86

9:40 8

Shell Temperature

Time Poured

45

77

Duration of Pour Multipour Number Cooling Bay Data

Cooling Bay - Position	3-9	3-10	
Length of Shroud Time	75	7.5	
Avezage Cooling Bay Temp.	88	88	

Number of Shells Poured	09	09		
Number of Criticals	0	1		
Number of Minors	3	0		
Number of Cavities	3	1		
Number of Good Shells	09	65		
Mumber of Shells with Porosity & crystallisation	0	Q		

TEST CNOUP TEST NUMBER TEST DATE

н 6 10/10/73

TEST GROUP TEST NUMBER TEST DATE

Multipour Date (First Pour)

185

981 180 187

Reservoir Temperature

184 180

Material Temperature Cup Temperature

Shell Temperature

Multipou Data (First Pour)	ta (Firs	t Pour,	
Reservoir Temperature	185	186	
Cup Temperature	179	180	
Material Terperature	184	183	
Shell Temperature	2,5	83	
Time Poured	7:18	7:25	
Duration of Pour	39	70	
Multipour Number	7	2	

Material Temperature	184	183	-	
Shell Temperature	33	83		
Time Poured	7:18	52:2		
Duration of Pour	39	07		
Multipour Number	~	2	-	

		•	
Cooling Day - Position	3-13	3-14	
Length of Shroud Time	52	25	
Average Cooling Bay Temp.	68	68	

X-Ray	X-Ray Results		
Number of Shells Poured	09	09	
Mumber of Criticals	2	0	
Number of Minors		10	
Number of Cavities	2	10	
Number of Good Shells	53	90	
Mumber of Shells with Porosity 6 crystallization	0	.0	

Cooling Bay Data

7:31

7:28

39

33

Duration of Pour Multipour Number

Time Poured

78

84

Cooling Bay - Position	4-1	4-2		
Length of Shroud Time	75	75		
Average Cooling Bay Temp.	87	87		

X-Ray Results

Number of Shells Poured	60	9	
Number of Criticals	0	1	
Number of Minors	7	6	
Number of Cavities	7	91	
Number of Good Shells	95	ōs	
Number of Shells with Porosity & crystallization	9	0	

N 1 10/12/73 TEST CROUP TEST NUMBER TEST DATE

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7
3
2
-
Skid Mumber

Multipour Date

מוני המלדות					
Meservoir Temperature	9/1	177	177	177	177
Cup Temperature	221	177	177	77.1	177
Material Temperature	176	176	42.	1	
Shell Temperature	×	7,	ž	,	7,
Time Poured	2.17		3.35	3,5	,
Duration of Pour	5		7	3	3 9
Multipour Number	2:	\ \ \	~	7	7

Cooling Bay Data

Cooling Rey - Position	3-5	3-6	3-8	3-10	3-10 3-12
Length of Shroud Time	7.5	7.5	7.5	51	2
Average Cooling Lay Temp.	86	98	86	85	26

X-May Results

Mumber of Shelis Poured	99	60	09	09	09
Number of Criticals	0	0	0	٥	0
Number of Minors	0	0	0	0	۰
Number of Cavities	0	0	0	٥	٥
Number of Good Shells	99	09	09	09	99
Mumber of Shells with Porveity & crystallization	0	0	0	0	0

N 1 10/12/73 TEST GROUP TEST NUMBER TEST DATE

Skid Number	9	^	80	6	2
Multipour Deta	Det.				
Reservoir Temperature	771	177	177	133	177
Cup Temperature	177	177	177	177	=
Material Temperature	175	176	176	176	≴
Shell Temperature	7.5	76	22	52	2
Time Poured	2.40	2 46	2.52	2 55	
Duration of Pour	72	65	52	53	52
Multipour Number	Ŷ	ç	,	,	,

Cooling Bay Data

Cooling Bay - Position	3-14	4-2	7-7	9-7	4-7
Length of Shroud Time	7.5	7.5	7.5	7.5	27
Average Cooling Bay Temp.	85	86	98	93	98

X-Ray Results

Number of Shells Poured	60	09	9	9	3
Number of Criticals	0	0	0	٥	٥
Number of Minors	0	٥	0	0	٥
Number of Cavities	0	ပ	0	٥	٥
Number of Good Shells	09	09	09	ş	8
Number of Shells with Porosity & crystallization	0	0	c	•	

z		16,12/23
CKO	NUMBER	DATE
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Skid Number
13
71
2
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=
Srid Number

Multipour Data (First Pour)

Reservoir Temperature	177	177	177	176	176
Cup Temperature	111	177	17.1	176	176
Material Temperature	177	176	177	177	177
Shell Temperature	72	7.7	2,5	2	7,7
Time Poured	3:02	3.06	3:10	3.13	3:16
Duration of Pour	22	\$\$	67	65	47
Mulcipour Number	2	2	2	2	2

3:29

3:26

3:23

3:19

87

ጸ

57

Duration of Pour Multipour Number

Time Poured

Cooling Bay Date

23

177 2 177 75

177 176

177 176 75

176 171 177 73

Reservoir Temperature

Material Temperature Shell Temperature

Cup Temperature

Multipour Data (First Pour)

1 10/12/73

TEST CROUP TEST NUMBER TEST DATE

Cooling Bay - Position	01-5	4-12	4-12	4-12 4-14 5-2	2-5
Length of Shroud Time	7.5	75	75	7.5	5,2
Average Couling Bay Temp.	98	67	98	98	83

Cooling Bay - Position	4-10	4-12	4-12	4-14	5-2
Length of Shroud Time	7.5	5.2	\$2	7.5	2
Average Couling Bay Temp.	86	67	98	98	83
•					
X-Nay	X-Ray Results				
Mumber of Shells Poured	3	50	9	09	
Number of Criticals	۰	0	٥	0	0
Number of Minors	0	0	۰	۰	0
Number of Cavities	0	0	٥	0	٥
Number of Good Shells	09	99	09	9	99
Number of Shells with Porosity & crystallization	0	Đ	0	۰	0.

Cooling Bay - Position	5-3	5-5	5-7	5-8	
Length of Shroud Time	7.5	7.5	25	27	
Average Cooling Bay Temp.	83	83	78	ž	
1					
X-May	X-Ray Results				
Number of Shells Poured	09	09	3	09	
Number of Criticals	0	٥	٥	٥	
Number of Minors	9	0		0	
Number of Cavities	0	0	0	G	
Number of Good Shells	09	60	9	09	
Number of Shells with Porosity 6 crystallization	0	0	0	0	

Cooling Bay Data

TEST CHOUP TEST NUMBER TEST DATE

Skid Number	1	2	3	4	
Multipour Date	Data				
Reservoir Temparature	179	180	180	180	
Cup Temperatuse	180	180	180	180	
Material Tomperature	180	180	081	180	
Shell Temperature	80	80	08	980	
Time Poured	5:49	5 52	\$5:5	5:59	
Duration of Pour	38	05	07	07	
Multipour Number	2	2	2	2	

Cooling May Date

Cooling Ray - Position	3-1	3-2	3-3	3-4	
Length of Shroud Time	7.5	22	52	22	
Average Cooling key Temp.	85	85	88	85	

Number of Shells Poured	99	9	09	09	<u> </u>
Number of Criticals	0	0	0	0	
Number of Minore	0	0	0	0	
Number of Cavities	0	0	0	۰	<u> </u>
Number of Good Shells	99	09	9	60	
Master of Shells with Poresity & crystallization	0	0	0	0	
					_

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0 2 10/15/73 TEST CHOUP TEST NUMBER TEST DATE

Multipour Date	Date				
Reservoir Temperature	178	180	180	180	
Cup Temperature	180	180	180	180	
Material Temperature	179	179	180	180	
Shall Temperature	91	06	56	95	
Time Poured	6:18	6 2 9	6:32	6.37	
Duration of Pour	42	73	52	43	
Multipour Number	2	2	2	2	

Cooling Bay Data

Cooling Bey - Position	3-5	3-6	3-7	3-8	-
Length of Shroud Time	7.5	25	7.5	75	
Average Cooling Bay Temp.	78	85	85	85	

Number of Shells Poured	09	09	09	09	
Number of Criticals	0	0	0	0	
Number of Minors	0	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	09	09	09	09	
Mumber of Shells with Porosity & crystallization	0	0	0	0	

0	. 4	10/15/73
TEST CROUP	TEST NUMBER	TEST DATE
		/73
0	٣	10/15/73
TEST GROUP	TEST NUMBER	TEST DATE

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Multipour Date	Jate				
Reservoir Temperature	190	190	188	188	
Cup Temperature	184	781	184	184	
Material Temperature	185	185	185	184	
Shell Temperature	76	06	76	96	
Time Foured	7:24	7:28	1:31	7:36	
Duration of Pour	34	34	35	36	
Multipour Number	2	2	2	2	

7:17

7:11

7:05

7:00

8

8

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77

22

8

Time Poured

38 185 187

182

183

Material Temperature Shell Temperature

Cup Temperature

184 186

182

85

184 182 182

Reservoir Temperature

Multipour Date

2

3-12

3-11

3-10

3-9

Cooling Bay Data

2 85

2 8

55 8 X-May Results

85 75

Duration of Pour	34	34	35	36	Duration of Pour
Multipour Number	2	2	2	2	Hultipour Number
				 	•
Cooling	Cooling Bay Data				Cool
Cooling Bay - Position	3-13	3-13 3-14	4-1	4-2	Cooling Bay - Position
Length of Shroud Time .	7.5	25	25	\$2	Length of Shroud Time
Average Cooling Bay Temp.	85	85	98	98	Average Cooling Bay Temp.

contride sey - costeron	2-13	3-14	4-1	7-7	
Length of Shroud Time	7.5	75	75	7.5	!
Average Cooling Bay Temp.	85	85	98	98]
•					
X-Ray	X-May Results				
Number of Shells Poured	09	09	99	09	
Number of Criticals	0	0	0	0	
Number of Minors	c	0	1	0	
Number of Cavities	0	0	1	0	
Number of Good Shells	09	9	59	09	
Number of Shells with Porosity & crystallization	0	0	0	0	······································

Number of Shells Poured	60	09	9	9	
Number of Criticels	0	0	0	0	
Number of Minors	0	0	0	٥	
Number of Cavities	0	0	0	0	
Number of Good Shells	99	09	09	09	
Mumber of Shells with Porosity & crystallization	•	0	0	0	

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TEST GROUP TEST NUMBER TEST DATE

1 10/18/73

Skid Number

Multipour Data (First Pour)

Reservoir Temperature	174	177	178	178	178
Cup Temperature	179	179	178	179	178
Material Temperatur:	176	176	176	176	176
Shell Temperature	3,2	52	7.5	76	7,5
Time Poured	5-41	3:45	5:51	5:56	5.59
Duration of Pour	95	85	62	97	47
Hultipour Number	2	,	2	2	2

Skid Number

Multipour Date (First Pour)

P 2 10/18/73

Test group Test number Test date

2

Reservoir Temperature	178	171	177	9/1	176
Cup Temperature	178	178	178	178	178
Material Temperature	176	177	176	17.1	176
Shell Temperature	86	85	85	85	8
Time Poured	6:05	6:11	6:15	6:18	6:22
Duration of Pour	50	47	87	47	1.7
Multipour Number	2	2	~	2	2

Cooling Bay Data

3-5 2 8

3-3 2

3-2 2

7

Cooling Bay - Position

75 89

Average Cooling Bay Temp.

Couling Bay Data

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10
Length of Shroud Time	75	7.5	7.5	75	55
Average Cooling Bay Temp.	8	06	06	90	8

60	Number of Shells Poured	9	9	09	09	3
U	Number of Criticals	-	2	2	1	0
0	Number of Minors	8	2	7	2	-
0	Number of Cavities	6	7	6		-
09	Number of Good Shells	51	56	51	57	59
0	Number of Shells with Porosity & crystallization	0	0	0		0

9

9 0

9

59

Number of Good Shells

Number of Cavities

0

9

9

9

89A

Number of Shells Poured

Number of Criticals

X-Ray Results

Shell 59 omitted from test, low pour.

Number of Shells with Porosity 6 crystallization

۵,		10/18/73	21/21/21
TEST GROUP	TECH MINER	ATOM HOUSE	1 m 1 cm
			7.3
	۵.	٣	10/18/73
	TEST GROUP	TEST NUMBER	TEST WATE

是一个人,也是一个人,我们是是一个人,我们是一个人,我们是一个人,我们是我们的,我们是这一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是这一个人,他们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们是一个人,我们就是一个人,我们

TEST NUMBE TEST DATE	TEST NUMBER TEST DATE	3 10/18/73						TET	-
Skid Number	2	-2	82	61	-	22		Skid Number	\neg
Multipour Data (First Pour)	Data (Fir	st Pour)				}		Maltipour	
Reservoir Temperature	181	186	186	186	<u> </u>	186	L	Reservoir Temperature	
Cup Temperature	186	186	185	184	_	ig Si		Cup Tenperature	
Material Temperature	185	185	781	187	_	781		Material Temperature	
Shell Temestatuse	\$	85	8,	8		78		Shell Temperature	
T'ene Posswed	, ,	7.27	7-32	\ \ \ \ \ \	<u> </u>	7 39		Time Poured	
Duration of Pour	63	87	4	0,7	4	2		Duration of Pour	$\neg \tau$
Wilston Nimber	,	2	2	2	"	<u> </u>		Multipour Number	
The state of the s			_						١

7:19

7:05

7:01

6:57

6:54

187 187

88 186

185

187

787

12

Data (First Pour)

184

184 22

184 22 7-7

3-14

51-5

7.5

3.11

Cooling Bay Data

2

88

Cooling Bay - Position	Length of Shroud Time	Average Cooling Bay Temp.
9-7	7.5	88
4-5	75	88
7-7	75	88
4-2 4-3 4-4	7.5	88
7-5	75	88
Cooling Bay . Position	Length of Shroud Time	Average Cooling Bay Temp.

Cooling Bay Data

			į	$oldsymbol{\perp}$					
							_		
4-6	۲۶	88		. 59A	0	8	8	15	0
4-5	7.5	88		99	1	11	12	87	. 0
4-4	75	88		09	\$	5	01	S	0
4-3	7.5	88		99	0	14	16	97	n
4-2	75	88	X-Ray Results	09	9	8	91	47	0
Cooling Bay - Position	Length of Shroud Time	Average Cooling Bay Temp.	. X-Ray	Number of Shells Poured	Number of Criticals	Number of Minors	Number of Gavities	Number of Good Shells	Number of Shells with Porosity & crystallization

A Shell 18 omitted from test, low pour.

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· 一下の下の大力では、

Number of Shells Poured	09	09	09	60	99
Number of Criticals	0	0	0	0	0
Number of Minors	٥	0	0	0	0
Number of Costites	0	0	0	0	0
Number of Good Shells	09	09	09	09	9
Number of Shells with Porosity & crystallization	O	Q	0	0	0

TEST GROUP	TEST NUMBER	TEST DATE
••	•	•
		9/73
0		10/19/73
TEST CNOUP	TEST NUMBER	TEST DATE

9 2 10/19/73

Skid Num

Skid Number	10	11	71	13	71
Multipour Date	Jate				
Reservoir Temperature	183	183	183	181	181
Cup Temperature	181	181	181	179	179
Material Temperature	180	181	181	181	182
Shell Temperature	80	79	81	82	81
Time Poured	2;49	2.51	2:53	2:56	2:59
Duration of Pour	•	•	39	38	7
Multipour Number	2	2	2	2	2

181 188 81

182 181

182

182 181

Reservoir Temperature

Multipour Date

179

179 181

179

Moterial Temperature Shell lemperature

Cup Temperature

83

43

45 8

> on of Pour Mo. capour Number

Time Poured

Cooling	Cooling Bay Data				
Cooling Bay - Position	01-7	11-7	71-7	4-12 4-13	4-14
Length of Shroud Time	7.5	7.5	7.5	75	2,5
Average Cooling Bay Temp.	85	85	98	- %	98

6:3

7-7

7-7

Cooling Bay - Position

Length of Shroud Time

Cooling Bay Data

Cooling Bay - Position	4-10	4-11	4-12	4-13	4-14
Length of Shroud Time	7.5	75	7.5	75	7.5
Average Cooling Bay Temp.	85	85	86	98	86
•					
X-Ray	X-Ray Results				
Number of Shells Poured	09	09	09		09
Number of Criticals	0	0	0	0	2
Number of Minors	0	0	0	0	1
Number of Cavities	0	0	0	-	3
Number of Good Shells	09	09	09	9	57
Number of Shells with Porosity 6 crystallization	0	0	0	0	0

Average Cooling Bay Temp.	87	87	87	87	87
X - Ray	X-Ray Results				
Number of Shells Poured	60	99	09	છ	9
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	09	09	09	09	09
Number of Shells with Porceity & crystelligation	O	0	0	0	0

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0	7	20
TEST GROUP	TEST NUMBER	TEST DATE
0	•	10/19/73
TEST CMOUP	TEST NUMBER	TEST DATE

Skid Number	9	7	8	6	Skid Number
Multipour Data	Date				Mul
Reservoir Temperature	183	182	183	183	Reservoir Temperature
Cup Temperature	181	:81	181	181	Cup Temperature
Material Temperature	180	180	181	180	Material Teaperature
Shell Temperature	18	18	82	88	Shell Temperature
Time Poured	2:36	2.39	2.42	2:45	Time Poured
Duration of Pour		38	07	37	Duration of Pour
Multipour Number	2	2	2	2	Kultipour Number
		Annual Contract of the last			

5.11

5:08

5:03

4:59

4:54

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3-3

3-2

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Cooling Bay - Position

Length of Shroud Time

Cooling Bay Data

Average Cooling Bay Temp.

Multipour Data

Charles temperature					
Shell Temperature	81	81	82	80	_
Time Poured	2:36	2.39	2.42	2:45	
Duration of Pour	•	38	40	37	
Multipour Number	2	2	2	2	
Cooling	Cooling Bay Data				
Cooling Bay - Position	3-6	3-7	3-8	3-9	
Length of Shroud Time	7.5	7,	7.5	7.5	
Const. Sall and Conf. and Conf.	83	87	87	87	

Length of Shroud Time	7.5	75	7.5	75	
Average Cooling Bay Temp.	87	87	87	87	
•					
X-Re)	X-Ray Results				
Number of Shells Poured	09	99	09	09	
Number of Criticals	0	0	0	0	
Number of Minors	O	0	0	0	
Number of Cavities	0	0	0	0	
Number of Good Shells	99	60	9	99	
Number of Shells with Poposity 6 crystallization	0	0	٥	•	

X-X	X-Ray Remilts				
Number of Shells Foured	9	39	09	09	09
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	09	09	09	09	09
Mumber of Shells with Porosity 6 crystallization	0	0	0	0	0

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TEST GNOUP TEST NUMBER TEST DATE
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_							
	Skil Number	٩	,	80	6	01	Skid Number
•	Multipour Data	Data					A LIM
	Reservoir Temperature	176	176	178	176	176	Reservoir Temperature
,	Cup Temperature	176	176	176	176	176	Cup Temperature
	Material Temperature	921	176	176	176	176	Material Temberature
	Shell Temperature	80	18	18	81	81	Shell Temberature
	Time Poured	5:17	5:32	5:35	5:39	5:43	Time Poured
	Duration of Pour	99	09	88	×	ž	Duration of Pour
	: Multipour Number	2	2	2	2	2	Multipour Number

6:25

6:21

6:18

6:13

176 176 176 81

Cooling Bay - Position	3-6	3-7	3-8	3-9	3-10	Cooling Bay - Position
Length of Shroud Time	7,5	75	7.5	2,2	22	Length of Shroud Time
Average Cooling Bay Temp.	87	87	87	87	87	Average Cooling Bay Temp

₹ \$

X-May Mesults

3-13

3-12

3-11

Cooling Bay Data

Number of Shells Poured	9	9	9	9	09	Number of Shells Poured
Number of Criticals	0	۰	٥		0	Number of Griticals
Number of Minors	0	0	0	0	5	Number of Minors
Number of Cavities	0	٥	۰	0	°	Number of Cavities
Number of Good Shells	09	9	9	09	09	Number of Good Shells
Mumber of Shells with Porosity & crystallization	0	0	0		0	Mumber of Shells with Porceity & creatalliseto

TEST GROUP Q
TEST NUMBER 5
TEST DATE 10/23/73

10/52/12 10/52/12

Multipour Data

Meservoir Temperature	177	178	179	179	180
Cup Temperature	177	177	176	176	921
Material Temperature	176	921	177	223	127
Shell Temperature	82	82	82	83	83
Time Poured	6:35	6:39	97:9	67:9	6.53
Duration of Pour	53	52	05	9,	
Multipour Number	2	2	2	,	2

Cooling Bay Data

Cooling Bay - Position	2-11	2-12	2-12	2-12 2-13	2-14
Length of Shroud Itme	7.5	75	92	27	75

X-Ray Results

Number of Shells Poured	60	09	09	09	09
Number of Criticals	0	0	0	0	0
Number of Minors	0	0	0	0	0
Number of Cavities	0	0	0	٥	0
Number of Good Shells	60	99	09	09	09
Number of Shells with Porcetty & arystallization	0	0	0	0	0

TEST GROUP Q TEST NUMBER 6 TEST DATE 10/24/7

Multipour Data

Reservoir Twayerature	182	182	182	182	182
Cup Temperature	180	180	180	180	179
Material Temperature	179	180	182	181	186
Shell Temperature	85	86	86	85	98
Time Poured	6.42	87:9	7.04	7 11	7 20
Duration of Pour	38	36	34	39	37
Multipour Number	3	۲۱	2	2	2

Cooling Bay Date

Cooling Bay - Position	£-:	7-9	6-6	8-9	6-10
Length of Shroud Time	7.5	7.5	75	2.5	7.5
Average Cooling Bey Temp.	81	81	32	82	82

Number of Shells Poured	9	09	09	09	09
Number of Criticals	1	0	8	3	۰
Number of Hinors	0	0	۲,	5	°
Number of Cavities	ı	0	22	4	0
Number of Good Shells	65	09	50	\$	9
Humber of Shells with Porosity 6 crystallization	0	0	ა	0	٥

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21 Skid Besher

		:	2	9	3
Multipour Data	Date				
Meservoir Temperature	182	182	182	182	1
Cup Temperature	380	180	8	13	1
Material Temperature	180	9	9		
Shell Temperature	*	ä) -	3	200
Time Poured		S	6	6	
	3	9:52	88	7:15	7:24
Duration of Pour	36	36	36	36	37
Multipour Number	~	7	,	,	,

Cooling Bay Data

Cooling Bay - Position	6-3	9-9	6-7	6-9	6-11
Length of Shroud Time	75	7.5	75	75	2
Average Cooling Bey Temp.	81	82	82	82	82

X-May Mesults

Manher of Shells Poured	09	ş	09	09	09
Mamber of Criticals	ŋ	-	7	3	•
Musber of Minors	0	c	2	٥	٥
Number of Cavities	٥	-	9	٦	٥
Number of Good Shells	3	69	54	23	9
Mumber of Shells with Potosity & crystallization	۰	c	0	э	

TEST CHOUP TEST MUBER TEST DATE

Bud our .

Skid Number		3	۶	7	6
Multipoer Data	bete				
Reservoir Temperature	182	182	181	180	182
Cup Tomperature	180	180	180	180	180
Material Temperature	180	180	180	181	081
Shall Temperature	85	85	. \$8	86	85

5.47 9

5:41 ñ

5:29

5:00

3

Duration of Pour Multipour Number

Time Poured

Cooling key Date

Cooling Bay - Position	4-1	4-3	4-5	2-7	6-7
Length of Shroud Time	7.5	7.5	75	7.5	2,5
Average Cooling Bay Temp.	8	%	89	89	8

X-May Medults

Number of Shells Poured	60	09	09	09	9
Number of Criticals	1	0	٥	1	۰
Musber of Minors	1	0	0	0	٥
Mumber of Cavities	2	0	0	1	۰
Number of Good Shells	88	9	09	88	9
Number of Shells with Porceity & crystallisation	0	0	o	o	0

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TEST CHOUP TEST NUMBER TEST DATE

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Skid Number

Reservoir Temperature 182 Cup Temperature 180				
rature				
	2 182	181	181	,
	0 180	180	180	2
Hater, al Temperature 180	08.	181	180	9
Shel: Temperature 86	_	1 8	**	:
Time Foured 5-25	5.34	├-	9	
Duration of Pour 36	15	×	7,	1
Multipour Number	^-	,	,	,

Cooling Bay Data

Cooling Bay - Position	77	7-7	9- 1	9-7	01-7
Length of Shroud Time	75	7.	2.5	*	ž
Average Couling Bay femp.	90	98	68	ક	8
				`	2

Number of Shells Poured	9	9	9	96	9
Number of Criticals	٥		c	٥	0
Number of Minors	е	=	0	5	0
Number of Cavities	0	-	o	ပ	٥
Number of Good Stells	9	\$6	60	09	9
Number of Shells with Porosity & crystallization	0	٥	0	o	c

TEST CHOUP TEST NUMBER TEST DATE

r	_
	18
	14
	10
	9
	2
	Skid Number

Multipour Date

Reservoir Temperature	182	182	182	182	182
Cup Temperature	1,78	178	180	177	5.7
Material Temperature	180) A	181	180	182
Shell Temperatura	85	8	83	87	88
Time Poused	5:18	5:34	70.9	7:04	7:23
Auration of Pour	39	39	39	37	29.
Multipour Number	2	2	2	7	~
				1	

Couling Bay Data

Cooling Bay - Posttion	3-2	3-4	9-6	3-€	3-10
Length of Shroud Time	7.5	75	7.5	7.5	75
Average Cooling Bay Temp.	84	85	88	86	85

Number of Shells Poured	09	9	09	9	3
Number of Criticals	o	_	°	7	۰
Number of Minors	0	۰	c	7	-
Number of Casteles	0	1	٥	80	,
Nurber of Good Shells	9	59	09	52	្ត
Number of Shells with Porosity & crystallization	0	٥	0	0	0

Q 11 10/25/73 TEST CROUP TEST NUMBER TEST DATE

Skid Number

TEST CHOUP TEST HUMBER TEST DATE

0 12 10/25/73 Skid Number

182 178 182

182 179 82

180

180 178

Reservoir Temperature

Cup Temperature

Multipour Data

178 180

ered moderner	200				
Reser of Tesperature	182	182	182	61	5
Ct. Jesperature	178	179	178	1	1
Material Temperature	180	181	980	2	1
Shell Temperature	98	78	98	ä	
Time Poured	5:25	85.5	5.58	3	<u>L</u>
Duration of Pour	39	36	3,	3	:
Hultfpour Number	2	,	,	,	, ا

7.26

9

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5 · 13

33

8

9

Multipour Number

Duration of Pour

Time Foured

8

8

83

180

180

Material Temperature Shell Temperature 8

86

Cooling May Date

3-9

3-7 2 86

3-5

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Cooling Bay - Position

Length of Shroud Time

Cooling Bay Data

2 98

2 85

2 85

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Average Cooling Bay Temp.

X-Ray Results

6-9	,	
6-7	7	8
9-7	2,5	8
4-4	27	88
4-2	7.5	68
Cooling Ray - Position	Length of Shroud Time	Average Cooling Bay Temp.

X-Rey Results

Number of Shells Poured	09	B	9	9	Ş
				3	3
Number of Criticals	۰	-	0	~	٥
Mumber of Minors	٥		·		1
					•
Number of Cavities	3	7	•	m	-
Number of Good Shells	[
	3	8	8	57	59
Musber of Shells with Porosity & crystallingeron	٥	0	0	0	

CONTRACTOR OF THE PROPERTY OF

Number of Shalls Poured	9	09	09	09	9
Number of Criticals	0	0	°	٥	"
Number of Minore	-	0	۰	0	~
Number of Cavities	-	٥	0	٥	4
tumber of Good Shells	59	9	9	9	3
tumber of Shells with	۰	0	0	3	~
ordaty & crystallisation					'

0 13 10/25/73

TEST CHOUP TEST HUMBER TEST DATE

61
15
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7
•
Skid Number

Multipour Data

Reservoir Temperature	182	182	182	182	180
Cup Temestature	178	178	178	178	176
Material Temperature	180	180	180	180	182
Shell Temperature	98	88	85	86	85
Time Purred	5:20	5:38	6:41	7:11	7 - 27
Duration of Pour	07	39	37	38	ž
Multipour Manher	2	2	2	2	2

Cooling May Date

233

Cooling Bay - Position	4-1	4-3	4-5	4-7	4-10
Length of Shroud Time	75	7.5	7.5	7.5	75
Average Cooling Bay Temp.	89	8	89	89	89

X-May Mesults

Member of Shells Poured	09	9	9	09	9
Number of Criticals	-	٥	0	1	4
Musber of Minors	۰	٥	0	O	-
Number of Cavities	-	٥	U	1	٠
Wimber of Good Shells	85	09	09	59	55
Mumber of Shells with	٥	٥	0	٠.	•

TEST CHOUP TEST NUMBER TEST DATE

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	Skid Number

Multipour Date

Reservoir Temperature	172	177	172	177	172
Cup Temperature	182	177	182	177	182
Material Temperature	176	177	176	176	176
	70	20	0/	20	70
Time Poured	1:34	1.35	1.38	07 :	1 43
Duration of Pour			•		
Multipour Number	_	(4	1	2	1

Cooling Bay Data

Cooling Bay - Position	2-13	2-14	3-1	3-5	ž
Length of Shroud Time	7.5	7.5	75	7.5	75
Average Cooling Bay Temp.	84	84	84	78	84

X-Ray Results

Number of Shells Poured	09	9	09	60	09
Number of Criticals	0	0	0	0	0
Number of Minors	0	٥	0	0	0
Number of Cavities	0	0	0	0	0
Number of Good Shells	09	03	09	09	09
Number of Shells with Porneity 6 crystallization	0	•	0	0	0

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TEST CHOUP Q TEST NUMBER 14 TEST DATE 10/26/73

Multipour Date

Reservoir Temperature				
	172	177	172	177
Cup Temporature 177	182	177	182	177
Material Temperature 177	17.1	176	177	176
Shell Temperature 70	02	20	0,	70
Time Poured	5 1:47	67-1	1 53	1.55
Duration of Pour	•	•		
Multipour Number 2	1	2	-	7

Cooling Bay Date

Cooling Ray - Pusition	3-4	3-5	3-6	2-6	9.
Length of Shroud Time	7.5	7.5	7.5	7.5	22
Average Cooling May Temp.	84	78	78	78	25

X-Ray Results

Number of Shells Poured 60 60 60 Number of Criticals 0 0 0 Number of Minors 0 0 0 Number of Cavities 0 0 0 Number of Cavities 0 0 0						
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Mumber of Shells Poured	90	60	09	09	9
0 0 0	Number of Criticals	0	0	0	0	٥
0 0 0	Number of Minors	0	0	0	0	٥
09 09	Number of Cavities	0	0	0	0	0
	Number of Good Shells	09	09	09	09	09
Number of Shells with 0 0 0 0 0 Percenty & crystallization	Number of Shells with Porosity & crystallization	0	0	0	0	0

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TEST GROUP Q TEST NUMBER 15 TEST DATE 10/30/73

Skid Number	1	2	3	7	s
Multipour Date	Date				
Reservoir Temperature	176	178	178	178	178
Cup Temperature	180	111	180	177	180
Material Temperature	177	176	177	176	176
Suell Temperature	62	09	29	62	79
Time Poured	12:54	12.55	12:57	12:59	1 02
Duration of Pour	-	•			
Multipour Number	1	2	~	2	-

Cooling Bay Data

Cooling Bay - Position	2-1	2-2	2-3	2-4	2-5
Length of Shroud Time	75	7.5	7.5	75	7.5
Average Cooling Bay Temp.					

Number of Shells Poured	90	3	09	9	09
Number of Criticals	0	9	0	0	۰
Number of Minore	0	0	0	0	۰
Number of Cavities	0	0	0	٥	٥
Marker of Good Shells	09	60	09	09	9
Example of Shells with Porvaire & creatallisation	0	0	0	0	٥

9 16 10/30/73 TEST CHOUP TEST NUMBER TEST DATE

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Multipour Data

Deservoir Temperature	179	178	179	178	179
Cup Temperature	177	180	177	180	171
Material Temperature	176	176	176	176	176
Shell Temperature	70	70	70	7.1	72
Time Poured	1:04	1:06	1:07	1:10	1:11
Duration of Pour	•	•	•	•	•
Multipour Number	. 2	1	2	1	2

Cooling hay Data

Cooling Nay - Position 2-6 2-7 2-8 2-9 Longth of Shroud Time 75 75 75 75 Average Cooling Bay Temp. 75 75 75						
Longth of Shroud Time 75 75 75 75 Average Cooling Lay Tamp.	Cooling Rey - Position	2-6	2-7	2-8	2-9	2-10
Average Cooling Lay Tamp.	Longth of Shroud Time	7.5	25	22	75	75
	Average Cooling Lay Temp.					

Number of Shells Poured	60	3	90	99	09
Namber of Criticals	0	0	0	0	0
Masher of Minors	0	٥	0	0	0
Mumber of Cavities	0	0	0	0	0
Number of Good Shells	90	09	09	09	09
Number of Shells with Poresity & crystallisation	0	0	0	0	0

0 16 10/30/73 TEST CHOUP TEST NUMBER TEST DATE

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Skid Number	=	12	13	14	1.5
Multipour Date	Date				
Reservoir Temperature	179	178	178	179	178
Cup Temperature	177	180	081	221	081
Material Temperature	176	176	7,1	176	ž
Shell Temperature	72	73	7.	9,2	2
Time Foured	1:14	1:15	1:18	1:21	1.23
Duration of Pour	•	•			
Multipour Number	7	1		2	_

Cooling Bay Data

Cooling Bay - Position	2-11	2-12	2-13	2-14	1-1
Length of Shroud Time	7.5	7.6	7.5	7.5	12
Average Cooling Bay Temp.					

X-Ray Results

Number of Shells Poured	60	09	09	09	0
Number of Criticals	0	0	0	0	٥
Number of Minors	0	0	0	0	0
Number of Cavities	O	0	9	0	٥
Mumber of Good Shells	. 60	99	09	9	ş
Number of Shells with Porosity & crystallization	0	0	0	0	0